FMG

DOCUMENT 701-90

SPECTRUM MONITORING PROCEDURES AND TECHNIQUES

FREQUENCY MANAGEMENT GROUP

RANGE COMMANDERS COUNCIL

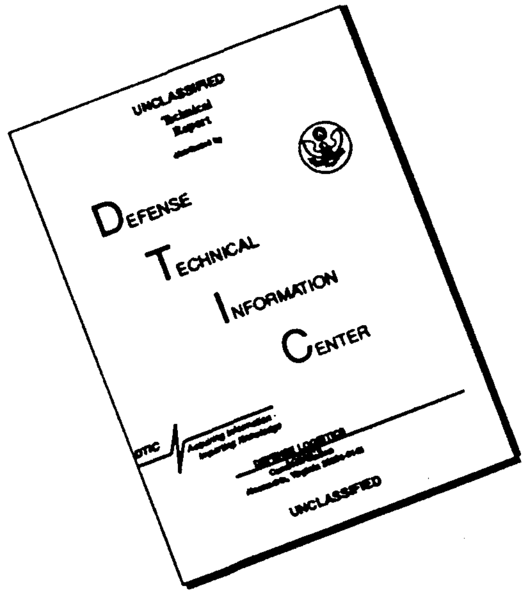
WHITE SANDS MISSILE RANGE
KWAJALEIN ATOLL
YUMA PROVING GROUND
ELECTRONIC PROVING GROUND

PACIFIC MISSILE TEST CENTER
NAVAL WEAPONS CENTER
ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR TEST CENTER

EASTERN SPACE AND MISSILE CENTER
MUNITIONS SYSTEMS DIVISION
WESTERN SPACE AND MISSILE CENTER
CONSOLIDATED SPACE TEST CENTER
AIR FORCE FLIGHT TEST CENTER
AIR FORCE TACTICAL FIGHTER WEAPONS CENTER

DISTRIBUTION STATEMENT A: APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

DISCLAIMER NOTICE



REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE July 1990	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

Spectrum Monitoring Procedures and Techniques

5. FUNDING NUMBERS

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Frequency Management Group
Range Commanders Council
White Sands Missile Range, NM

8. PERFORMING ORGANIZATION REPORT NUMBER

RCC Document 701-90

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Range Commanders Council
STEWS-SA-R
White Sands Missile Range, NM 88002

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

same as block 8

11. SUPPLEMENTARY NOTES

New document

12a. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

It is intended to provide basic information on sources of radio interference, methods used to direction find (DF) emitter locations, procedures used to monitor frequency spectrum use, and ways to protect emitter systems.

14. SUBJECT TERMS

emitter systems, DF, direction find emitter

15. NUMBER OF PAGES

439

SECURITY CLASSIFICATION OF REPORT	SECURITY CLASSIFICATION OF THIS PAGE	SECURITY CLASSIFICATION OF ABSTRACT	LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	NONE

DOCUMENT 701-90

SPECTRUM MONITORING PROCEDURES AND TECHNIQUES

JULY 1990

Prepared by
Frequency Management Group
Range Commanders Council

Published by

Secretariat
Range Commanders Council
U.S. Army White Sands Missile Range
New Mexico 88002

PREFACE

This document was prepared by the Range Commanders Council (RCC) Frequency Management Group (FMG) in response to RCC task FM-2, Spectrum Monitoring Procedures and Techniques. It is intended to provide basic information on sources of radio interference, methods used to direction find (DF) emitter locations, procedures used to monitor frequency spectrum use, and ways to protect emitter systems. In addition, the document lists DF stations and assets of the RCC FMG membership used by test range frequency management to monitor and control the spectrum.

TABLE OF CONTENTS

APPENDIXES

LIST OF TABLES

LIST OF FIGURES

SCHEDULING

The first step towards operating an emitter on a test range is to contact the local frequency manager to establish a schedule. Since restricted radio frequency bands and operations are different at each test range location, most testing is accomplished by sharing the spectrum available with all range users. The telemetry bands in particular require spectrum activity scheduling.

The objective is to resolve scheduling conflicts prior to operations. When two programs or projects request to use the same spectrum, their activity can be separated by guard bands, discrete frequencies, time, or operating locations (terrain masking). Priorities assigned to each program usually dictate which program will be scheduled first; however, use of priorities to schedule activities should be avoided and only considered as a last resort. When a scheduling conflict cannot be resolved using these techniques, it is brought to the attention of the responsible program managers. When scheduling activities involve other federal or nonfederal agencies, it is in the best interest of program managers to be as flexible as possible.

MANAGEMENT'S RELATIONSHIP TO MONITORING

Complete surveillance of spectrum activity and usage is an expensive process, and the results are limited to the signals in the immediate vicinity of the monitoring system. Therefore, monitoring is usually undertaken to detect unauthorized use and to obtain information that is not available from the normal spectrum management files or from analysis and simulation. Because the functions of spectrum management and spectrum monitoring require close coordination, management of both functions should be in one office. In summary, spectrum management

a. provides spectrum monitoring with official lists of assigned frequencies; however, signals not on these lists can be assumed to be operating without proper authorization and are of special interest to monitoring;

b. provides general guidance to spectrum monitoring on particular bands, on support level required, on suspected problem areas, and on future monitoring requirements; and

c. assigns specific jobs to spectrum monitoring that involve interference resolution, electromagnetic compatibility (EMC) problems, quality control measurements, utilization reports, and special measurements.

Spectrum monitoring provides information to spectrum management on clear frequencies for assignment and general band crowding assessments. Furthermore, spectrum monitoring provides feedback to spectrum management on the general state of technical and administrative discipline in radio bands, identifies particular problem areas, and enforces spectrum management decisions by identifying transmitters not in compliance with rules and by causing appropriate action to be taken. In general, spectrum management should provide guidance and direction to spectrum monitoring activities, especially in the area of long-term planning for the type and amount of support needed from the monitoring program. It is vital that continuing close coordination be maintained between these functions to ensure that spectrum management does not base policies on monitoring results that are misleading.

ANALYSIS

To obtain additional detailed information on the technical or operational characteristics of emitter systems, spectrum analysis is used. This process might typically include a detailed measurement of the emission spectrum of a transmitter or the antenna pattern of a microwave antenna. These measurements can be made to provide information needed in a particular EMC analysis, to verify compliance with the characteristics specified in a particular frequency assignment record, or as part of an acceptance process to ensure that a particular type of equipment will operate compatibly with other emitter systems operating in the same spectrum. Finally, a spectrum analysis might be made merely to ascertain that a given transmitter was operating within allowable limits.

The requirements of each test range differ according to the mission. Radio frequency (RF) analysis from a calibrated source can provide managers with solutions, engineers with alternatives, and historical data for files. A measurement technique must be selected that will allow various types of signals to be measured in a quantitatively useful way. Thus, the analysis system should employ a variety of bandwidths and video signal processing that is selected individually for the signal being measured. Radio frequency analysis can differentiate between signals by measuring and cataloging the following parameters:

Frequency

Center frequency is the most important parameter to frequency managers and is the reference point for all frequency administration matters. In addition, center frequency is the initial measuring point for all RF analysis.

Bandwidth

Bandwidth is the second most important parameter in cataloging an RF emitter. Emitter bandwidth actually defines the amount of RF spectrum required for a particular application. Interference control is based upon the accurate measurement and cataloging of this parameter.

Amplitude

Amplitude is actually the square root of the quantity measured, which has the dimension of power in watts, or decibels (dB) referred to a reference power. The radiated watts of a known RF emitter can be monitored over a period of time to verify any user equipment changes.

Bearing

The azimuth and (if applicable elevation) angle between one or more receivers of known location are used to determine the source of an unknown emission.

Time

Potential interference sources can be located after the emitter has stopped transmitting by recording time parameters. If accurate time recordings are taken when interference starts and stops, these times could be compared to the scheduled RF range activity of range users. Where range activities match the recorded interference times, further analysis and investigation may reveal the source. The trouble with this type of problem solving is that most ranges do not record or schedule all spectrum activity.

Modulation

Detecting differences in modulation can help discriminate between two emitters operating on the same frequency. As authorization for different types of modulation operating in the same portion of spectrum increases, the importance of this parameter increases. Being able to demodulate may be the only way of identifying an unknown source.

Radar Characteristics

There are several characteristics of pulsed systems that can be used to distinguish radars operating on the same frequency. By cataloging and recording these differences and by identifying changes in operating parameters, interference between systems can be located. These important characteristics of pulsed systems are

Pulse Width. A parameter of time that measures the radar pulse at the half-power points located between the rise and fall times of each pulse.

Pulse Repetition Frequency (PRF). A parameter that measures the frequency of radar pulses per second; usually measured in time, then converted to frequency.

Antenna Spin Rate. A parameter that measures the time between main antenna lobe peaks, usually converted into revolutions per minute.

Antenna Pattern. A measurement of signal strength plotted over time that can be used to determine the antenna pattern; reveals the main and side lobes of the radar antenna in a linear plot.

Polarization

Signal polarization can be used to identify an emitter. An incorrectly characterized polarization makes a difference of at least 3 dB and may approach 20 dB or more in typical situations. Location of a fixed signal from two or more locations on the basis of signal strength alone is rarely possible. Knowing proper polarization may allow emitter identification.

NOTE

Any analysis products that link a particular platform or aircraft to specific frequency analysis information become sensitive in classification and the appropriate security guidelines must be followed.

INTERFERENCE CONTROL

Spectrum surveillance and analysis measurements are useful in resolving the cause of interference with authorized transmitters. Such measurements may detect the presence of unauthorized transmitters causing the interference, the more subtle conditions resulting from a combination of transmitters, or the unintended spurious emissions. Although a wide variety of spectrum measurement and engineering analysis techniques may be needed to resolve some types of interference, good spectrum measurements often play an important role in this process. Accordingly, spectrum monitoring is often useful in identifying transmitters involved in the interference.

Because unauthorized transmitters are the most common cause of interference, there will often be a close association between the ability to solve interference problems and the ability to detect and to identify unauthorized transmitters. A major problem with detecting unauthorized transmitters is that it is often difficult to separate the authorized from the unauthorized signals. This separation is acute in the crowded telemetry bands where the scheduled emission shares the same spectrum as the unscheduled interfering signal. Detection of unauthorized signals can sometimes be accomplished by aural monitoring on frequencies where authorized users have complained of interference, or where frequency assignment records show no authorized assigned users. Direction-finding (DF) processes, mobile tracking vans, and aural monitoring intelligence are helpful in identifying and in locating unauthorized transmitters after they have been detected.

Some sources of interference are not truly interference at all, but an artifact of the type or location of the receiving system being used. Interference may occur when received signals cause cross modulation within the receiving system, or occur because local oscillators in the receiving system interfere with one another. Such interference is a significant contributor to problems, and it is rare that someone notices that the receivers and the received signals are spaced by one or two intermediate frequency (IF) bandwidths. The subsequent paragraphs contain information relating to identification and location of radiated signals and sources of broad and narrow band interferences.

Identification and Location of Signals

Normal transmissions such as amplitude modulation, frequency modulation, continuous wave, teletype, and facsimile can be identified by call letters, frequency, date, transmission time, and emission type. The sources of these signals can normally be located by directing an inquiry through appropriate channels.

The identification and location of interference signals is usually more complicated. The aural and visual presentations provided by various equipment must be studied carefully to achieve favorable results. Written material on interference, in addition to that presented here, is readily available and should be used. Information on various signals as seen on panoramic adapters is particularly useful. Identification of most aural signals is associated with narrow and broad band interference. Material on audible indications associated with interference is provided in table 1.

TABLE 1. AUDIBLE INDICATIONS ASSOCIATED WITH INTERFERENCE

Audible Interference Type	Possible Source and Mechanism
Whistling and squeals	Co-channel, adjacent channel, harmonics, IF oscillations, intermodulation
60 or 120 cycle hum	Power line noise, fluorescent lights, power supply hum
Popping	Ignition systems, magnetos
Cracking	Regulators, corona discharge, static discharge
Sputtering, loud and continuous	Arc welders, high frequency apparatus, diathermy, arc lamps
Co-channel	Occurs when the interfering signal and the desired signal share (at least in part) the same receiver passband.
Image frequency	Occurs when the image frequency of a desired signal is strong enough to not be fully attenuated in the resonant receiver circuits used to reject the signal. (The signal mixes with the local oscillator frequency and is passed through.)
Undesired transmission	Co-channel, adjacent channel, harmonics, intermodulation, intermediate frequency

TABLE 1 (Con.). AUDIBLE INDICATIONS ASSOCIATED WITH INTERFERENCE

Audible Interference Type	Possible Source and Mechanism
Clicking, regular, or irregular	Electric calculating machines, code code machines, ignition, mercury arc rectifiers, relays, switches, teletypewriters, thermostatic control
Buzzing	Buzzers, vibrators
Whining	Rotating machines, radar modulator pulse
Frying	Electric arcs, continuously arcing contacts
Adjacent channel	Occurs when the undesired signal's passband is entirely outside that of the desired signal but cannot be eliminated by the receiver.
Harmonics	Occurs when a signal, generated in the input circuits, is produced at the receiver IF by local oscillator frequency harmonics; received signals other than the desired signal.
Intermodulation (communication receiver)	Occurs with simultaneous reception of two or more signals which combine in receiver input circuits to produce the desired frequency to which the receiver is tuned or in response to a spurious response frequency of the receiver.
Cross modulation	Occurs when the modulation of an undesired signal is impressed upon a desired signal in the receiver input circuits.
Intermodulation (radar receivers)	Results when a combination of (radar receivers) local oscillator (LO) frequency and spectral line frequency produces a signal of sufficient amplitude at the receivers IF, or when the separation between spectral lines is equal to the IF of the receiver.
Shock excitation	Occurs when a short duration pulse signal is applied to a resonant circuit, setting up damped oscillation at the natural resonant frequency of the tuned circuits for a few cycles.

Sources of Narrow Band Interference

Narrow band interference consists of co-channel, adjacent-channel harmonics and other signals at a distant frequency. Undesirable response appears in a narrow tuning range when these signals are detected. Most signals of this type are listed in table 1. Co-channel and adjacent-channel transmissions consist of authorized or unauthorized transmissions present simultaneously with a desired signal. Unusual propagation conditions, frequency spectrum crowding, excessively high power use, improper maintenance procedures, or off-frequency operations may cause such signals.

Harmonics can be present in the radiated output of a transmitter employing a class "C" final output stage. This condition is caused by faulty amplification characteristics of class "C" operation. Intermodulation and cross-modulation signals can be generated if two transmitter signals are mixed in a common nonlinear impedance and then transmitted normally. These intermodulation products can occur if electromagnetic energy from one transmitter is coupled to another. Parasitics are undesirable oscillations generated in a transmitter from combinations of stray inductance and capacitance. Other spurious outputs consist of undesirable signals associated with frequency multiplication or modulation present in a transmitter output. In some cases, receivers act as transmitters by radiating energy at their local oscillator frequency or harmonics.

Radar transmitters can cause interference in other radars when operating with excessive or high-level sidebands. Drifting from the assigned frequency in a radar network or nonsynchronized pulse recurrence frequencies between two radar systems can cause interference.

Sources of Broad Band Interference

Broad band interference is principally caused by transients formed when current carrying circuits are opened or closed. It consists of a wide range of frequencies detectable by receivers over a broad band tuning range. There are many sources of broad band interference. One of the most common sources is power-line interference caused by sudden changes in potential because of current surges, corona, arcing, or interruption of a power circuit. Fluorescent lights can create such interference because of normal gas ionization within the tube or by defective components. Similarly, arc welding interference is generated by the arc and associated equipment. Electric ignition interference is caused by transients in low and high tension ignition circuits, while rotating machinery causes transients because of commutation arcing or static discharge. Also, such apparatus as diathermy equipment, X-ray machines, or induction heaters can emanate RF interference.

Since a radar modulator pulse is made up of harmonics of the basic PRF, these harmonics may be received directly from the radar antenna or from metal portions of the radar equipment. Consequently, intermittent connections and static discharges from wires or other metallic objects may cause transients. In addition, ambient noise interference may be generated by such factors as static discharge (thunderstorms, precipitation static, cosmic noise and discharges from snow, dust, rain, and hail).

DIRECTION FINDING

Direction finding is an art because accuracy is directly dependent on operator training and proficiency. There is no single approach to locating an unknown emitter, only a complex mix of interrelated processes.

The environment in which a DF antenna is expected to operate must be taken into account because radio wave propagation, reflection, and reradiation distorts DF measurements. Therefore, the accuracy of the DF system must be ensured by protecting the antenna from nearby reflections, collocated emitters and reradiation from collocated antennas.

DF Systems

The two common systems used to direction find are fixed and mobile. The methods of location differ with each system. The advantages and disadvantages of both fixed and mobile systems must be understood to select the best method for direction finding.

Fixed DF Sites

Advantages. The ability to provide 24-hour a day, real-time, DF information is the main advantage of operating with fixed sites. With automation of DF and monitoring equipment, any manpower restrictions can be overcome. Fixed sites allow the range to establish what areas are monitored and what areas are not. The cost of maintaining and operating a fixed site is lower than a mobile site.

Disadvantages. The fixed-site method requires the use of three fixed stations to locate emitters. The requirement for the third site comes from emitters operating on the same bearing as any two DF sites. No matter how much planning or engineering takes place, the signal that causes the most trouble will most likely be outside of the fixed site's ability to receive.

Mobile DF Sites

Advantages. The ability to DF is based on the overall system sensitivity, the beam width of the antenna, and the distance from the emitting source. Because sensitivity and detection distance are directly proportional, as the sensitivity increases so does the ability to DF greater distances. The emitting source distance is usually unknown, not controllable, and beyond a fixed site's sensitivity. With mobile DF systems, sensitivity can always be compensated by driving around until the signal is received. Mobile DF allows the emitting source to be identified with an on/off sequence.

Disadvantages. The mobile system is manpower intensive, usually requiring two individuals: one driver and one system operator.

Interior space is at a premium with the vehicle's size restricting off-road capability. Vehicle maintenance, road conditions and weather further reduce the mobile system's advantages.

Direction Finding Techniques and Guidelines

NOTE

For Operational Security (OPSEC) reasons, when reporting on or coordinating interference that has been linked to a location, platform, or specific equipment, handle that information as classified until contact with the user has been completed and the information has been identified as unclassified.

There are several factors which will degrade the DF's ability to accurately determine the line of bearing (LOB) from the DF antenna to the emitter antenna. It is important to know that these factors will degrade any DF system's performance, some systems more than others and some factors more than others. An appreciation and knowledge of these factors can help the operator to get the best performance from the DF system. Listed below are the major error factors which should be taken into consideration when deploying for operational use or evaluation testing:

a. signal polarization
b. signal path
c. site location
d. DF processing instrument
e. emitter source
f. mobile platforms
g. mast mounting
h. other error sources

Each of these error-producing factors is discussed briefly. Keep in mind that in most cases there is more than one error-producing factor. Moreover, the total errors are a combination of each of the individual error factors.

Signal Polarization Errors

Most radio direction finders operating in the low very high frequency (VHF) through high ultra high frequency (UHF) frequency range are designed to operate against vertically polarized signals, because the majority of the "of interest" target emitters are from mobile and fixed site communication transmitters using vertical (whip) antennas. Most of these antennas have an omni-directional radiation pattern (particularly handheld, manpack, and mobile units mounted on vehicles).

There are, however, other radiation polarizations used in this frequency range. They are slant (45 ^{o}, circular (left and right), and horizontal polarization. Commercial frequency modulation (FM) broadcast stations (88 to 108 MHz in the United States) use slant, circular, and horizontal polarization. Television (TV) uses horizontal predominantly. Because these commercial stations are not vertically polarized, confusion may result when the DF system tries to make a bearing measurement on the station. Many times, this anomaly shows up as a 90 or 180^{o} error on automated DF processing systems. For the most part, since the location of these stations is known and because there are special DF antennas which can be operated against them, it is not very important to determine an LOB on one of these or similar type of polarized emitter. It is recommended that commercial FM and TV stations not be used to evaluate the DF system performance or be used as reference targets for calibration because of the possible DF error caused by these polarizations.

Signal Path Errors

Path errors result from the direction changes of the radio wave from its "directional path" (shortest distance between two points). The factors which cause these changes are reflection, scattering, absorption, reradiation, and refraction. The effects of these factors usually result in more than one radio wave front (from the same emitter) arriving at the receiver antenna (DF system) simultaneously. This phenomenon is more commonly known as "multipath." Multipath signals can arrive at the receiver antenna at varying amplitudes, phases, and times. If the sources of multipath are relatively fixed and do not change, the DF system will typically indicate a wrong bearing. The bearing degree is dependent upon the total levels and directions of arrival of the multipath signals. Should the multipath contamination vary such as when the emitter or DF antenna is moving, the resultant bearing will average to the more correct value. The effects of multipath for fixed emitters and DF sites can be reduced by using specially designed "wide aperture" antenna systems. For the most part, wide aperture antenna systems are large, more costly, and not readily transportable, or easily wielded. A detailed description of each of the path error factors is discussed next.

Reflections. Radio waves can strike and bounce off such objects as mountains, hills, buildings, bridges, towers, metal objects, and people. When this bouncing happens, it is termed "reflection." The amount and angle of reflection is dependent on the relative size, shape, composition, and position of the object. If the reflective object is near the DF antenna, large errors can occur, so the DF antenna should be kept away from such reflectors as much as possible.

Scattering. Scattering is a phenomena usually attributed to radio waves entering the ionosphere. Upon entering the ionosphere, the radio wave may be scattered in several directions causing the polarization of the radio wave to change from vertical to horizontal. It is very difficult to obtain accurate DF bearing on received signals "scattered" from the ionosphere. This scattering is usually the cause when dealing with "skywaves."

Absorption. Absorption occurs when the radio wave is obstructed by natural or man-made objects and reduced in level. Typically, it becomes a source of DF error indirectly when the "direct path" signal is absorbed and another indirect path signal (multipath) becomes predominant. The DF system will, as it does in all cases, show the bearing of the strongest signal or combination of signals.

Reradiation. Reradiation occurs when the radio wave strikes an object, usually metal, and causes that object to behave as though it were an emitter itself. This secondary emitter produces radio waves (reradiates) which can also be received by the DF system. Since these reradiated radio waves are from a different source (angle) than that of the direct path radio waves, a resultant bearing error is produced.

Refraction. When radio waves pass from one medium to another, they may be bent. This bending is similar to the way light bends through a lens. The bending redirects the radio waves and gives an erroneous bearing reading. For example, dry air may be considered one medium while moist air is considered another. This refraction can be seen in areas such as deserts, lakes, and coastlines.

Site Location Errors

Site location errors are produced when the DF antenna is placed in an area where the path error factors, described previously, can affect the DF accuracy. An ideal site, sometimes called a "class A" site, is a place where the effects of these factors can be kept to a minimum. No ideal site may really exist; consequently, a site with varying degrees of compromise is usually the case. Such a site location should be the highest point in the vicinity and be as far as possible from other objects to reduce the effects of reradiation and reflections which cause multipath. Objects such as hills, cars, trucks, wire fences, power lines, radio antennas and towers, water towers, buildings, foliage, streams and lakes should be as far as possible from the DF antenna. Table 2 delineates some guidelines in selecting a site location.

When a DF system is intended for mobile or transportable use, it obviously becomes increasingly more difficult to select an operation site meeting all the criteria shown in table 2. The operator will have to make the best of the situation. In these situations, the confidence factor for each bearing will have to be learned through experience. Some factors indicating a high confidence bearing are

a. bearing display is fairly constant (fixed site) over time, that is, 1 to 3° jitter using and automated DF system;

b. no signal fading is present;

c. the signal is reasonably strong and active for a long period of time (greater than 30 seconds); and

d. no other signals are heard at the same time on the received frequency.

If multipath is suspected, the operator may, if possible, move the DF antenna a few inches and observe the bearing display for a change. Remember, the operator cannot be near the DF antenna when taking bearings. If there is little or no change, it can be assumed that there is no multipath present for that signal; however, there may be multipath present for other signals, even at the same frequency.

TABLE 2. RECOMMENDED DISTANCES TO OBSTRUCTIONS (FIXED SITE)

Obstruction	Recommended Distance
High cliffs and mountains	7 kilometers
Hills and deep ravines	1 kilometer
Lakes, rivers, and streams	300 meters
Railroad tracks	300 meters
Power and telephone lines	300 meters
Large metal towers	250 meters
Water towers and chimney stacks	250 meters
Wire fences	250 meters
Large buildings	250 meters
Small buildings	250 meters
Large trucks	200 meters
Buried metallic conductors	200 meters
Automobiles	150 meters
Small trucks (1/4 ton)	150 meters
Scattered trees and shrubs	100 meters
Personnel	25 meters

When using an automated DF system on the move (DF in track and hold mode), the bearing display unit indicator will shift the indicated bearing up to $\pm 90^{\circ}$. In this situation, the operator can easily integrate the average bearing by eye. Although when moving, particularly in the urban environment, accuracy is more difficult to achieve because the display moves or jitters more. When traveling in larger towns or cities, particularly between buildings, the radio waves may be funneled down the streets. This "canyon effect" indicates that the emitter is located forward, rearward, or to the side of the DF vehicle. The operator then drives toward the signal and as the vehicle with the DF system approaches the intersection, the operator will see the bearing indication change and point more to the origin of the emitter. Once operators acquire the "feeling" for the system, they will learn to trust the bearing readings.

Automated DF Processing (Instrument) Error

The current industry/market series of automated direction finder processors have a processing accuracy of $\pm 1^{o}$. This accuracy is related to the processor's ability to determine a bearing from an ideal source. Usually, this source (for testing purposes) is a special test fixture which generates a suitable output for the DF processor to evaluate and to produce a bearing indication. By using a special test fixture, the DF processor can be aligned and calibrated to meet its specified performance easily. While some industry DF processors evaluate the signal to 0.1^{o}, which suggests a resolution of 0.1^{o}, it has been found that it is not beneficial or practical to display the bearing to any resolution better than 1^{o}.

There are some factors which can affect the DF processor (instrument) bearing accuracy. The major factors affecting instrument processing ability, and consequently instrumental error, are signal level and quality. To the operator, a signal, in the 30 to 40 dB range, would be a very good signal-to-noise ratio (S+N/N) and would sound clear to the operator with little or no noise (other than the DF processing signal). Receiver signal strength would be better than -50 dBm. Another signal quality factor, contamination, occurs when more than one signal occupies the same frequency bandwidth; for example, two or more transmitters operating at one time.

Emitter Source Errors

Emitter source errors occur at the transmitting (emitter) site. Normally, they are due to the type of transmitting antenna used, collocated obstructions, and local terrain. In most cases, the DF operator has no control over these conditions. The major effect on DF is redirection of the transmitted signal. This redirection is similar to an "antenna beam formation" where the antenna radiation pattern is modified from an omni-directional pattern to a directive beam. The DF error is then more often caused by reception of an indirect radio wave reflecting (bouncing) off another object such as a hill or large building far away. The indirect radio wave received has become larger than the direct radio wave and consequently affects the bearing accuracy.

In those instances where the transmitting antenna is nearby, these procedures should be followed:

a. Reflectors should not be nearby.

b. The signal polarization must match the DF system.

c. The distance between the transmitter antenna and the DF antenna should be greater than 10 wavelengths (far field). Minimum distance in meters = 300/(F (in MHz) X 10).

d. If the transmitter output power is too high, the DF system receiver will be blocked.

e. Clear line of sight between the DF antenna and the transmitting antenna must be maintained.

Mobile Platform Errors

Depending upon the overall size and shape of the vehicle, there may be some frequencies where a significant bearing error can occur. In many cases, there are only 5 to 10 frequencies where the vehicle may grossly affect the bearing accuracy. These worst case errors have been measured as high as 35° but typically are less than 15°. The vehicle effects on bearing accuracy are primarily due to either the vehicle acting as a nonsymmetrical ground plane for the DF antennas or the vehicle resonating with the arriving signals creating standing waves on the vehicle, or both factors could apply.

For the most part, ground plane interaction is fairly broad creating moderate bearing errors typically no higher than 10°. Vehicle resonances, on the other hand, tend to be narrow in frequency (less than 10 percent bandwidth) and are attributed to higher bearing errors, typically 10 to 18° with very few errors as high as 35°. Vehicle resonance may occur at any longitudinal or diagonal section of the vehicle where the wavelength or wavelength fraction of the received signal is equal to that sectional length.

Frequencies associated with a particular vehicle where resonance can occur resulting in significant bearing errors can be calculated with the following formula:

F1 = 308 X L ±10%

F2 = 616 X L ±10%

where

F1 = first frequency in MHz of potential error

F2 = second frequency in MHz of potential error

L = longitudinal or diagonal length of hood, roof, or truck

If the hood dimension is different from the roof dimension, there may be multiple groups of suspected frequencies. For automobiles with nonrelated length-to-width ratios, the effect of resonance is difficult to predict for all frequencies.

NOTE

> **In cases of airborne or shipborne deployments, resonance may occur on any structure (masts, rails, antennas, and wing lengths).**

Mast Mounting Errors

Many deployments of DF antennas require the antenna be mounted on a mast. In these instances, the resonance effects of the mast itself should be accounted for. At certain frequencies, the mast on which the DF antenna is mounted will appear to be a resonant stub. This resonant effect will be at subharmonics or harmonics of a wavelength (for example, 1/8, 1/4, 1/2, 1, 2). Should the mast become an efficient resonator, significant bearing errors may occur. Mast resonances may be eliminated or reduced by

a. making mast of nonmetallic structure,

b. placing wavelength of insulating mast section between the mast and the DF antenna (see **NOTE** below),

c. placing ferrite toroids (Q1 and Q6 ferrite materials offer good performance) on the mast and RF down feed control cable to detune it, and

d. placing radial ground planes at the base of the antenna. Consult manufactures for part numbers.

NOTE

> **Care must also be taken to eliminate the resonant effects of the RF down feed control cable from the DF antenna.**

Other Error Sources

Other sources of DF error may be attributed to the items listed next.

a. Imprecise alignment of DF antenna to its north reference or other reference point.

b. Inappropriate automatic DF processor front panel setting which may include incorrect bearing offset, calibration not set to zero, incorrect antenna frequency range selected, threshold set too high or too low, air/ground set to incorrect mode, 0/180^{0} reference set incorrect, calibrate/DF switch left in calibrate, low batteries or power input.

c. Inappropriate receiver front panel setting which may include IF bandwidth set too wide or too narrow, automatic gain control (AGC) set to manual or fast, receiver off tuned, squelch or carrier operated relay (COR) set incorrect.

d. Inappropriate automatic DF processor input levels from receiver with IF or audio set too high or too low.

e. Incompatible IF or audio inputs.

f. DF antenna output not connected to correct receiver antenna input when using receivers with selectable RF inputs.

NOTE

Some receivers may have front panel selectable antenna inputs which may be set to an incorrect input.

g. Received signal is outside the operating frequency range of the DF antenna or system.

h. The emitter antenna and the DF system antenna not clear of their respective Fresnel zones.

i. Insufficient or asymmetric DF antenna ground plane. Many mobile applications having an automatic DF antenna installed on the roof may have higher errors noted around 45, 135, 225, and 315^{0} because of this effect.

j. Incorrect antenna receiver interconnect coax cable.

NOTE

This cable must be 100 percent shielded to eliminate "signal ingress." Regular RG58 or RG59 cables are not suitable.

k. Platform resonances at various frequencies. This phenomenon usually occurs at functions of the received signal wavelengths, for example, 1/8 wavelength and 1/2 wavelength (see Mobile Platform Errors).

l. The received signal may be arriving at an extremely high elevation angle outside of the optimum performance area of the DF antenna. This high elevation angle may be noted at lower frequencies where skywaves are present and when operating against airborne signals, that is, automated DF processor on the ground target emitter in the air or vice versa.

Operators of systems must thoroughly acquaint themselves with the inherent errors produced by their system when operating in the DF mode. Accordingly, a daily DF calibration should be made using a known source, from a known distance, operating at a known power level. This calibration provides a daily status of the DF system's performance and deterioration over time.

When direction finding on an omni-directional antenna, the signal strength continually increases as the mobile DF system approaches the source. When direction finding on a directional antenna, the directional antenna's gain characteristics affect the signal strength readings. While trying to DF a microwave link, DF operators who rely too heavily on signal strength readings may become confused when the signal strength changes as the mobile DF system moves outside of the antenna's beam width.

When operating a spectrum analyzer to measure power or emission, do not overlook selection of the proper resolution bandwidth. The displayed signal distortion (convolution theory) must be held to a minimum to produce accurate measurements.

a. If the analyzer's resolution bandwidth (IF) is less than the bandwidth of the signal, only power is being measured. The analyzer captures the peak signal strengths while sweeping over the analyzer's span, and the narrow IF bandwidth prevents the display from distorting the signal amplitude. However, the narrow IF distorts the display bandwidth by failing to capture the entire signal's bandwidth all at once. (Signal strength is accurate, emission bandwidth is not).

b. If the analyzer's resolution bandwidth (IF) is equal to or greater than the bandwidth of the signal, emission is being measured. With each sweep, the analyzer captures the entire signal's bandwidth. The wide IF bandwidth allows the display to accurately present the entire signal; however, the analyzer's signal amplitude will not be accurate. (Emission bandwidth is accurate, signal strength is not).

SPECTRUM MONITORING

As the number of projects and programs increases at each range location, so does the demand for more efficient spectrum use. As a result, each test range has to protect the limited amount of spectrum resources available for range operations. See appendixes A through M for procedures used at various ranges. While scheduling spectrum activity will reduce user conflicts, monitoring is the management tool used to ensure range safety, schedule compliance and spectrum efficiency. The task of frequency monitoring involves the extensive use of RF surveillance and analysis equipment for searching and scanning the RF spectrum to identify signals that may interfere with any electronic range facility. Thus, the purpose of monitoring is to ensure an interference free environment prior to and during operations.

Accordingly, spectrum monitoring includes planning, contract quality control, range safety, and encroachment.

Planning

Spectrum information monitoring provides a data base on frequency efficiency and use that managers and engineers rely on to plan future requirements. The data base also establishes a historical record of spectrum signal activity which must be considered when adding more users to an established net (increasing frequency efficiency) or assigning a new operating frequency (based on use). In addition, spectrum monitoring data allows management to make decisions based on historical signal activity instead of spectrum availability. This data permits the frequency manager to select, at a glance, the frequency with the lowest potential for conflict and the highest potential for success.

Quality Control

Spectrum use by automated weapons systems has increased the demand for additional monitoring. Quality control of seeker systems, threat parameters, and test results is now being accomplished by monitoring spectrum activities. Questions frequently asked include Did the unit under test receive the correct signal? Was there another signal interfering? Was the correct modulation used? Was the output power at the correct strength? Because the answers to these and other questions may make the difference between a project's success or failure, spectrum monitoring provides the project engineer and contract specialist with the documentation needed to reach a decision.

Range Safety

Range safety relies on fast, accurate, real-time monitoring to provide the range safety officer the best possible data during critical periods. Moreover, monitoring can provide the protection necessary to ensure a safe RF environment prior to operations. During operations, flight termination frequencies for unmanned test platforms are high interest range safety items because the range safety officer does not want to discover an unknown signal during a live-fire test.

Encroachment

As the local communities around the test ranges grow, encroachment on the range spectrum becomes more of a problem. The range frequency manager protects the interests of the test range and ensures the best response from the local Federal Communications Commission (FCC) and the nonfederal user by monitoring range assets and spectrum use, by identifying unknown signals received and their sources, and by eliminating any interference as soon as possible. Usable range spectrum must be maintained. However, current trends indicate that all usable range spectrum will have been saturated long before any range closes because of population growth, noise control abatement, or poor air quality.

TELEMETRY MONITORING INSTRUCTIONS

Telemetry monitoring protects range users from unintentional RF interference and ensures that all frequency users are duly authorized and scheduled and that they adhere to all tolerance, emission type and bandwidth restrictions imposed.

Duties

a. Monitor spectrums (1435-1535, 2200-2300 and 2310-2390 MHz), identify signals, measure signals and frequency, and log all signals intercepted.

b. Inform station supervisor of all pertinent information concerning monitoring position including tolerance violations, unauthorized emissions, interfering signals, and noncompliance with instructions.

c. Operate with other monitoring sites and mobile facilities as required.

Equipment

Spectrum and signal analysis, frequency measurement, direction finding.

Signal Analysis

a. Type

(1) Frequency modulation (FM)

(2) Amplitude modulation (AM)

(3) Continuous wave (CW)

(4) Modulated continuous wave (MCW)

(5) Telemetry

(6) Pulse

b. Bandwidth 60 dB down from unmodulated peak

c. Relative signal strength

Method

a. Check the operations schedule for daily telemetry frequency assignments to ensure that frequency assignments do not conflict. All assignment discrepancies shall be referred to the frequency manager for appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Identify all signals intercepted with those frequencies assigned to projects for daily operations. If a signal cannot be identified as an authorized assignment, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations such as the mobile facility.

(1) If the signal is determined to be of local origin, frequency management will dispatch a mobile facility to the suspicious area to locate and identify the transmission source.

(2) If the signal is determined to be of remote origin, attempt to identify the origin area such as Los Angeles or desert activities. Frequency management will direct a mobile facility to locate and to identify the transmission source so that coordination can be achieved.

d. Measure all signals intercepted to ensure that local assignments conform to frequency tolerance requirements and that signals of remote origin are sufficiently spaced from local signals, so they do not cause interference.

(1) If a signal of local origin is measured out of tolerance, notify frequency management for corrective action.

(2) If a signal of remote origin is measured within 250 kHz of a local assignment authorized for a scheduled operation, notify frequency management of the possible interference source. Provide complete information concerning signal characteristics and enter time of notification in the log. Frequency management should be notified of any signal, regardless of frequency separation, when interference appears likely.

(3) When periodic measurements of a local assignment show abnormal transmitter operations such as excessive frequency drift, spurious emission, and low relative signal strength, a separate log detailing such discrepancies should be maintained. Using this information, a conclusive report can be prepared for the project concerned so that corrective actions can be taken.

Reporting Process

The monitoring station telemetering position operator will take all actions concerning telemetry interference and will fill out an interference report with all required information concerning the complaint. The operator will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference, giving full details and requesting assistance. Further, the operator will keep frequency management fully informed of investigative progress, so a conclusive report can be made to the branch head.

If the interfering signal appears to be of local origin, frequency management will dispatch a mobile facility to the area (as determined by direction-finding techniques), so the source of transmission can be located and identified. When the offender is identified, frequency management and the branch head will be notified so appropriate action can be taken. If the interfering signal is determined to be of remote origin, frequency management will notify the branch head.

Platform/Aircraft Checkout

The checklist (see figure 1) should be maintained as data base input on all telemetry transmitters being used. Because there is a difference in modulation between each program, platform and aircraft under test, frequency management and range operations must be aware of any modulation changes during the test cycle. The frequency manager also needs to know the exact bandwidth being used by each program and project operating on the test range for frequency deconfliction and scheduling purposes. Such bandwidth information is also used by range operations' telemetry receiver systems to establish the IF receiver filter bandwidth that can obtain the best data for a particular test.

RADAR MONITORING INSTRUCTIONS

Application of the following radar monitoring instructions will protect range users from unintentional RF interference and will ensure that radar and beacon frequencies are compatible.

Duties

a. Monitor spectrum from 90 MHz to 40 GHz by

(1) determining radar and beacon requirements,

(2) analyzing to ensure compatibility,

(3) identifying intercepted signals using triangulation with other facilities and identification by known bearings or fingerprints,

(4) measuring local signals, and

(5) logging all signals.

b. Assist frequency management or endorse silence requirements as necessary.

c. Be aware of electromagnetic compatibility operations and their effect on local operations.

d. Handle station interference problems (local) associated with spectrum monitoring.

e. Keep frequency management informed of all pertinent data concerning monitoring position.

f. Operate with other frequency monitoring sites and mobile facilities as required.

AIRCRAFT CHECKOUT

(GENERAL CHECKOUT)

Aircraft ________ Tail# ________ Date: ________ Time: ________

HARDCOPY GRAPHS

Modulation Voltage Into Transmitter	☐
Spurious Products Double Frequency No Modulation	☐
Spurious Products Single Frequency No Modulation	☐
Rf Bandwidth 60 Db Down	☐
Fm/Fm Subcarrier Modulation Spectrum Display	☐

INFORMATION

Transmitter Sensitivity ________ KHz ________ (RMS/PEAK/PP) per Volt ________ (RMS/PEAK/PP)

Transmitter Specifications ☐ | Antenna Type ________

Power Split ________ % Top ________ % Bottom

Calculated ERP ________ Watts (Top) ________ Watts (Bottom)

Pre-modulation Filter ☐ Yes ☐ No Type ________

Coordinating Engineer ________

ADDITIONAL MEASUREMENTS

Power Measured At Antenna Input Ant #1________ dBm Ant #2 ________dBm

Modulation Into Transmitter ________VPP

Antenna Location

Figure 1. Aircraft Checklist.

g. Maintain close liaison with other operating positions concerned with the same operation.

Equipment, Transmission Type, Frequency Measurements and Analysis

a. Band covered is 90 MHz to 40 GHz.

b. Signal types transmitted are frequency modulation, amplitude modulation, continuous wave, modulated continuous wave, telemetry, and pulse.

c. Frequency measurements are made direct and with a transfer oscillator.

d. Two types of signal analysis used are panoramic presentation and pulse analysis.

Method

a. Check daily operations schedule to determine operational radar and beacon requirements identified with specific aircraft, drone, or missile installations. Analyze radar and beacon frequency configurations to ensure that frequency assignments do not conflict. It is imperative that the beacon interrogation frequency be separated at least 10 MHz, and when possible 15 MHz, from any other signal sources. Refer all frequency assignment discrepancies to frequency management for appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Compare all signals intercepted with range radar and beacon assignments being used for daily operations. If a signal cannot be linked with range assignments, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations. If the signal is determined to be of local origin, frequency management will dispatch the mobile facility to the area of suspicion to locate and identify the source of transmission. If the signal is determined to be of remote origin, attempt to identify the area of origin. Frequency management will request assistance from the area frequency coordinator in such cases.

d. Measure all signals intercepted to ensure that local radars conform to authorized frequency assignments and that signals of remote origin are sufficiently spaced from local assignments so as not to cause interference. This is particularly important in the case of beacon interrogation frequencies. If a radar frequency appears to have been changed without prior coordination, notify frequency management who will take appropriate action. If a signal of remote origin is measured within 10 MHz of a beacon interrogation frequency being used for a scheduled operation, notify frequency management of the possible interfering source. Provide complete information concerning the signal characteristics and enter the time of notification in the log. Frequency management should be notified of any signal, regardless of frequency separation, when interference appears likely. When daily periodic measurements of a local assignment show abnormal transmitter operation such as excessive frequency drift, spurious emissions, and low relative signal strength, notify frequency management.

Reporting Process

a. The frequency monitoring station radar position operator will take all actions concerning radar interference and will fill out an interference report with all required information concerning the complaint. The operator will immediately monitor the frequency involved, notify the other monitoring stations of the reported interference, giving full details and requesting assistance. Further, the operator will keep frequency management fully informed of investigative progress so that a conclusive report can be made to the branch head. If the interfering signal appears to be of local origin, frequency management will dispatch the mobile facility to the suspicious area (as determined by direction finding techniques), so the source of the transmission can be located and identified. When the offender is identified, frequency management will be notified so that action can be taken. If the interfering signal is determined to be of remote origin, frequency management will request assistance from the area frequency coordinator.

b. When radar silence is in effect for a scheduled operation, ensure that the prescribed frequency band is clear. All discrepancies will be referred to frequency management for corrective action.

c. All EMC operations, either of local or remote origin, will be monitored to ensure that harmful interference is not encountered on frequencies using restricted bands.

RADIO COMMAND CONTROL/DRONE MONITORING INSTRUCTIONS

Radio command control/drone monitoring is employed to detect extraneous radio command signals and to ensure proper operation of control station transmitting equipment. The monitoring station recording position operator will

a. coordinate marking of all charts being made at each monitoring station;

b. record the operation number, date, frequency, operator, and recorder number being used at the beginning and end of each chart;

c. monitor assigned communication circuit for status of missile launch or drone take-off;

d. start recorders prior to missile or drone radio command control checkouts and identify each radio command/control function precheck with the controlling station when applicable;

e. validate operational schedule by checking teletype. If precheck from a particular station appears abnormal, notify frequency management who will take corrective action before launch;

f. mark recording with all pertinent data including countdown (beginning at the minus-two-minute warning or when the drone is spotted), zero time (missile launch or drone takeoff), transfers of control showing controlling station, and time of landing or splash, if applicable;

g. ensure range timing is on;

h. include countdown of firing operation (beginning at the two minute warning) if a command controlled missile or drone is being used as a target; and

i. observe panoramic adapter to ensure that control signal is of sufficient strength to maintain positive control during transfers of control. If the control station is at an extended range, request that another facility provide this data.

VOICE COMMUNICATIONS MONITORING INSTRUCTIONS

Voice communications monitoring protects range projects from unintentional radio frequency (RF) interference and ensures that all frequency users are duly authorized and adhere to all tolerance, emission type, and bandwidth restrictions imposed. The following sections describe various aspects of the voice communication monitoring process.

Duties

a. Monitor voice communications spectrum by

(1) identifying all signals used on operations and all apparent signals, and

(2) analyzing signals using measurement, signal strength and signal characteristics of AM, FM, Pulse, CW, and MCW.

b. Keep frequency management informed of all pertinent information concerning position including tolerance violations, unauthorized emissions, interfering signals, and noncompliance with range instructions.

c. Conduct operational readiness checks for such project equipment as pen recorders and be sure chart recordings are made of all air/surface launches for interference verification.

Method

a. Check operations schedule and teletype for daily command control frequency assignments. Ensure that frequency assignments do not conflict. All assignment discrepancies shall be referred to frequency management for appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Compare all signals intercepted with those frequencies assigned to projects for daily operations. If a signal cannot be identified as an authorized assignment, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations. If the signal is determined to be of local origin, frequency management will dispatch the mobile facility to the suspicious area (as determined by use of direction finding techniques), so the source of the transmission can be located and identified. When the offender is identified, and the signal source is one that has not been authorized, a radio discipline violation report will be issued. If the signal is determined to be of remote origin, attempt to identify area of origin such as Los Angeles or desert activities. Frequency management will direct the mobile facility to locate and identify the transmission source so that coordination can be achieved.

d. Ensure that local assignments conform to frequency tolerance requirements and that signals of remote origin are sufficiently spaced from local signals so as not to cause interference. If a signal of local origin is measured out of tolerance, notify frequency management who will take corrective action. If a signal of remote origin is measured within 1.0 MHz of a local assignment authorized for a scheduled operation, notify frequency management of the possible interference source. Provide complete information concerning signal characteristics and enter in the log the time of notification. Responsible persons will be notified of any signal, regardless of frequency separation, when interference appears likely. When periodic measurements of a local assignment show such abnormal transmitter operations as excessive frequency drift, spurious emission, and low relative signal strength, notify frequency management.

Reporting Process

The monitoring station command control position operator will take all actions concerning command/control interference and complete an interference report containing all required information concerning the complaint. The operator will immediately monitor the frequency involved, and notify the other monitoring stations of the reported interference, giving full details and requesting assistance. Further, the operator will keep frequency management fully informed of investigative progress so that a conclusive report can be made to the branch head. If the interfering signal appears to be of local origin, frequency management will dispatch the mobile facility to the suspicious area (as determined by use of direction finding techniques), so the source of the transmission can be located and identified. When the offender is identified, notify the frequency management/branch head who will take appropriate action. If the interfering signal is determined to be of remote origin, frequency management will notify the branch head.

MISCELLANEOUS MONITORING INSTRUCTIONS

Miscellaneous monitoring is conducted to protect range users from unintentional RF interference and to ensure that users are duly authorized and adhere to all restrictions imposed.

Duties

a. Monitor communications circuits and make spot checks of all daily assigned circuits to

(1) measure frequency of users,

(2) check call signs of users,

(3) check for interference,

(4) check for circuit procedures, and

(5) check for noncompliance of applicable DOD instructions.

b. Monitor permanently assigned radio relay links, propagation study transmitters and aids to navigation to

(1) measure frequency,

(2) check bandwidth,

(3) check relative signal strength, and

(4) monitor for interference.

c. Keep frequency management informed of all pertinent information concerning position.

Method

Measure all signals to ensure that assignments conform to frequency tolerance requirements and that signals of remote origin are sufficiently spaced from local signals so that they do not cause interference. If a local assignment is measured out of tolerance, notify frequency management for corrective action. If a signal of remote origin is measured close enough to a local assignment to cause interference, attempt to identify the area of origin. Notify frequency management upon identification. When periodic measurements of local assignments show such abnormal transmitter operations as excessive frequency drift, spurious emissions, or low relative signal strength, complete a log entry detailing all discrepancies, so a conclusive report may be made to the project concerned to ensure corrective action is taken.

Actions

The monitoring station miscellaneous position operator will take all actions concerning frequency interference and will complete a report containing all required information concerning the complaint. The operator will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference giving full details and requesting assistance. Further, the operator will keep frequency management fully informed of investigative progress so that a conclusive report can be made to the branch head.

APPENDIX A

AIR FORCE FLIGHT TEST CENTER

EDWARDS AIR FORCE BASE, CALIFORNIA

AIR FORCE FLIGHT TEST CENTER

EDWARDS AIR FORCE BASE

FREQUENCY CONTROL AND ANALYSIS SECTION

The Frequency Control and Analysis (FCA) section functions as the spectrum enforcement and control arm of the Air Force Flight Test Center Frequency Management Office. The FCA provides direct mission support on all RFI/EMI studies, ECM requests, restricted band testing, and surveillance analysis services which are required by DOD users or Air Force contract facilities on or around the R-2508 National Test Range Complex.

The FCA section uses a wide variety of electronic test equipment mounted in a mobile facility to provide real-time analysis data in a calibrated output at either remote range locations or next to the aircraft on the flight line. The FCA van is self supporting with onboard AC voltage, air conditioners, and computer support for long duration signal monitoring. The FCA facility is capable of receiving and processing (RF) signals while in motion. The small size of the van allows for off-road conditions or restrictions that are easily overcome. Equipped with state-of-the-art surveillance equipment and using the latest monitoring techniques, the FCA section supports and protects the AFFTC's spectrum interests.

Point of Contact

The FCA section can be reached 24 hours a day by contacting the 1925th Communications Squadron, Job Control, at (805) 277-3444, DSN 527-3444, or by the AFFTC, Command Post, at (805) 277-3040, DSN 527-3040. During normal duty hours, the FCA can be reached at (805) 277-8448, DSN 527-8448.

Requests for Support

Project and program priorities are scheduled and handled on a secondary basis to safety of flight, safety of life, and telemetry interference. The FCA section has recently procured a second mobile facility which will relieve most of the scheduling conflicts currently being experienced when requesting support.

Operating Parameters

By December 1989, the FCA's spectrum monitoring range will be 20 Hz to 110 GHz with direction finding capabilities from 150 MHz to 110 GHz. Pulse width measurement capabilities range from 100 MHz to 110 GHz at 10 nanoseconds pulse durations. The overall system sensitivity of the FCA's spectrum monitoring system is -100 dBm from 20 kHz to 10 GHz, -90 dBm from 10 GHz to 22 GHz, and -80 dBm from 22 GHz to 40 GHz.

Block Diagram

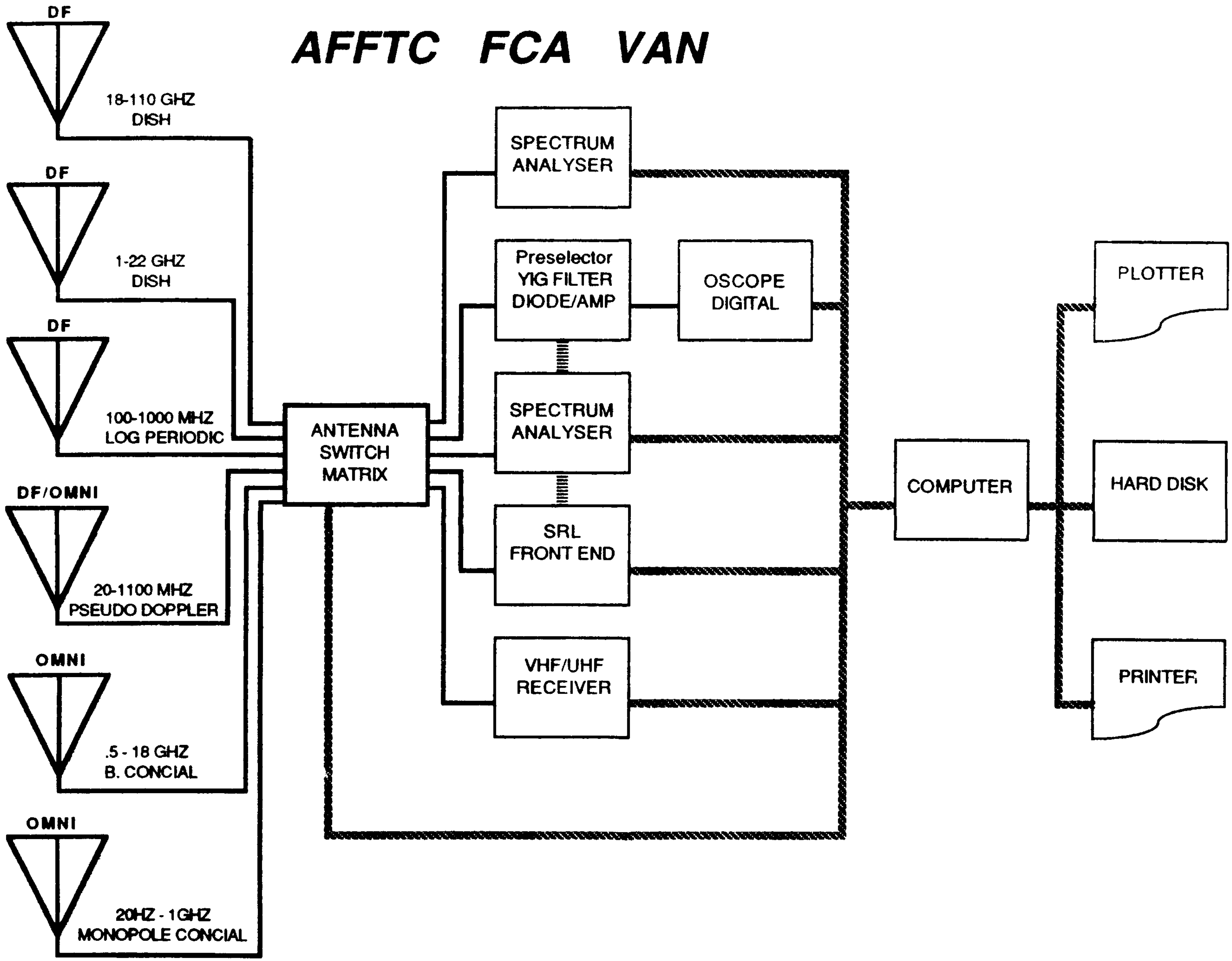
The areas discussed next are antenna system, signal processing, and automation.

Antenna System. There are six antennas covering the frequency range of 20 Hz to 110 GHz used by the FCA facility operators. These antennas are connected to an IEEE-488 bus controlled switching matrix. Any of the 10 inputs can be connected manually to any of the 10 outputs from the front panel or computer controlled.

Signal Processing. Two analyzers and receivers are used to collect data from the spectrum. One analyzer is directly interfaced to the SRL front end receiver. The SRL front end receiver only masks the analyzer, allowing the sensitivity to be lowered while retaining all the analyzer's functions. It also provides a wider IF bandwidth for pulse analysis in the lower frequency ranges. The second analyzer allows the operator to perform manual analysis while the first remains under computer control collecting data. The second receiver is used to monitor and to control normal voice transmissions without impacting the operations of the analyzers. This second receiver also allows the system operator to monitor the test communications from standoff locations without interfering with close aircraft ground support maintenance crews. Another method of pulse measurements is obtained by use of a Preselector to filter received RF signals present while providing about 30 MHz of bandwidth. The Preselector's YIG filter is tuned by the spectrum analyzer when the Span function is set to 0 Hz, allowing the pulse analysis measurements to be detected by a diode then amplified prior to being displayed on a digital oscope. While this method requires a strong signal input, it has proven to be a highly accurate measurement.

Automation. Software is a problem because most vendors only offer programs directed toward INTEL, ELINT or TEMPEST measurements. As a result, the bulk of redundant software requirements and applications are being met by locally designed programs. Output products can either be on paper, in the form of X-Y spectrum plots, numerical printouts, or stored to a hard or floppy disk for future analysis. The FCA computer uses an IEEE-488 bus to control the FCA test equipment and receivers.

AFFTC FCA VAN



APPENDIX B

ATLANTIC FLEET WEAPONS TRAINING FACILITY

ROOSEVELT ROADS, PUERTO RICO

ATLANTIC FLEET WEAPONS TRAINING FACILITIES
P.O. BOX 3023 FPO MIAMI, FL 34051-9000

FREQUENCY CONTROL AND ANALYSIS SYSTEM

POC: DOD AFC PUERTO RICO
TEL: (809) 889-2687 COMMERCIAL
831-5223 AUTOVON

SECTION 1.0

INTRODUCTION TO THE FREQUENCY CONTROL AND ANALYSIS SYSTEM

1.1 SYSTEM OVERVIEW

A limited number of frequencies are allocated for range operations. Furthermore, infringements to these frequency franchises regularly and repetitively occur, which significantly decrease operational effectiveness. The fundamental purpose of the FCA complex is to achieve the maximum effectiveness and utilization of the restricted frequency spectrum allocated for range operations. These FCA system objectives are accomplished by two collateral but different techniques; i.e., (1) spectrum monitoring and surveillance, and (2) management and control of the allocated frequency spectrum. The execution of the frequency surveillance and monitoring system function by the FCA complex is accomplished by remote FCA systems. All frequency surveillance and monitoring data obtained by the FCA complex is supplied by the remote FCA systems. Furthermore, the utilization of the FCA complex to facilitate other range activities is also required. The primary range objectives that are accommodated by the FCA complex are monitoring of the frequency environment during EW exercises, and correlating the frequency environment data measured with EW exercise activities. Additional range operations personnel are provided with frequency spectrum data from the FCA complex.

These fundamental FCA objectives impose certain constraints on the FCA complex. In order to satisfy overall FCA requirements within the confines of these constraints, the FCA complex is structured to provide efficient utilization of system resources. This structure provides orderly command and control sequences to ensure efficient data acquisition and management.

1.2 SYSTEM DESCRIPTION

The FCA complex consists of two basic subsystems, a command master and a remote FCA subsystem. The fundamental responsibility of the FCA remote site is the real-time acquisition of frequency spectrum data. The command master controls the operation of each remote site, provides central command and control capabilities of the FCA complex from a central location, provides complete system analysis and display capability for the FCA complex, and provides the interface between the FCA and non-FCA range systems.

The hardware required to implement the FCA command master and remote site systems is dependent on the primary and secondary functions of each subsystem. The fundamental responsibility of the FCA Remote Site is the real-time acquisition of frequency spectrum data. The primary function of the command master is to control and coordinate the operation of remote sites, provide complete system analysis and display capability for the FCA complex, and provide the interface between the FCA and non-FCA range systems.

Figure 1-1 is a block diagram of the FCA system. The communication group separates the Command Master System (CMS) from the Remote Master System (RMS). Each system and group within the system is discussed in detail in the succeeding pages of this manual.

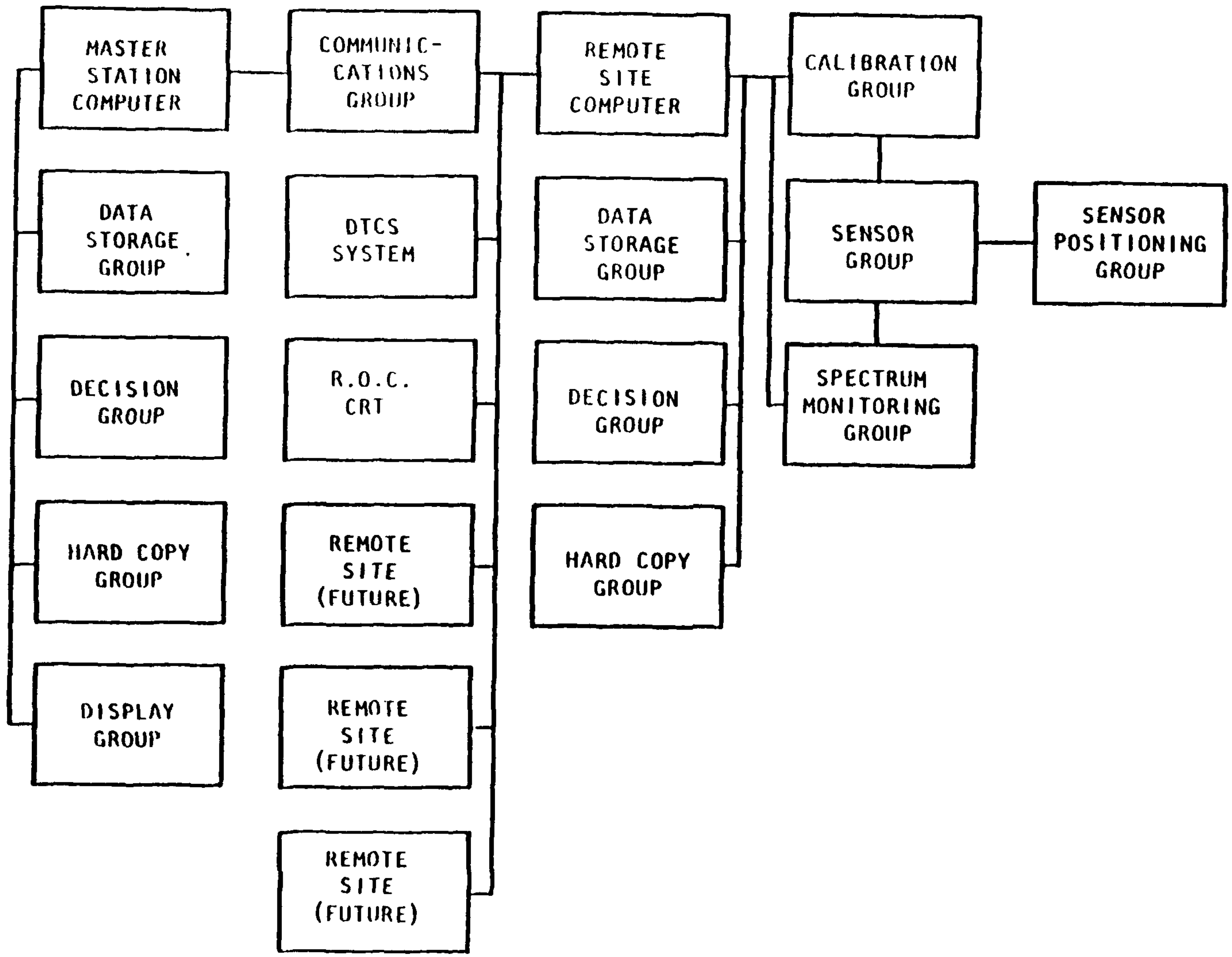


Figure 1-1 FCA System Equipment Block Diagram

SECTION 2.0

FCA SYSTEM SOFTWARE

2.1 GENERAL ORGANIZATION

The FCA complex consists of two basic subsystems, a command master system (CMS) and Remote Master System (RMS). The system software is organized to obtain maximum efficiency of system resources within the operating constraints of each subsystem. In order to satisfy the overall FCA requirements at the desired efficiency level, the system software is defined and developed in functional module form.

The modular approach has several advantages over other software organization techniques. Among these advantages are improved operating efficiency and expandability.

For operating purposes each functional module is self-sufficient, thus eliminating needless loading and reloading of redundant programs while the system is performing a specific function. In this way, operational continuity of the FCA complex is maintained. Software modular organization will enable future FCA expansion to be accomplished with minimal integration difficulties.

The FCA subsystem programs are divided into three subsections; control modules, functional modules, and support modules. The control modules contain all of the data area and programming necessary to establish and maintain operational authority over the particular FCA site. This includes both on-site and off-site control. The functional modules are organized to perform each site's primary responsibility. The support modules help maintain the system software and enable continued development

2.1.1 SOFTWARE ORGANIZATION

The FCA software satisfies three fundamental requirements which are:

A. Executive Control

B. Functional System Objectives

C. System Support

The executive routines control or indicates control of the FCA complex. This control includes creation of remote site job scenarios, the control of external command requests and also the listing, displaying and storage of data acquired by the remote site. The functional objective of the system is to provide the analysis capability required for control and management of the frequency spectrum and maintenance of the system. Additional software capabilities are in the form of system support for both on-line and off-line programs.

2.1.2 CONTROL

The control functions are utilized to initiate and maintain operation of the FCA complex. The decision module provides the system operator with the facilities for commanding the various equipments in the FCA complex in both the manual and automatic modes of operation. The system's operator controls are designed with minimum complexity in order that operation is not restricted by a myriad of actions. The system modules perform their tasks automatically in response to either a system operator request or a particular job definition. This places system command decisions with the operator and regulates the system control tasks to the remaining control modules.

The executive module provides complete multiprogramming capability in a real-time environment.

Disc files are utilized as storage for the functional modules so they will be rapidly available to the system. This easy access to system component modules enables the executive to coordinate all system activities other than those functions that are directly connected to interrupt levels or off-line. The executive loads non-resident tasks, and provides a log of its activities. Tasks are initiated on the basis of time of day, elapsed time, external interrupt, round robin, operator request, or another task.

2.1.3 FUNCTIONAL

The FCA system objectives are accomplished by two collateral, but different techniques, i.e., (1) spectrum monitoring and surveillance, and (2) management and control of the allocated frequency spectrum.

The implementation of the FCA objectives requires the utilization of several functional software modules. These modules are designed to provide complete system analysis and display capabilities and perform system maintenance.

2.1.4 SUPPORT

Support programs include all auxiliary or primary programs that are necessary for operation of the major additional FCA programs. These programs include FCA I/O controllers, command decode, programs linkage, some diagnostic routines, input/output data handlers, etc.

2.3 SPECTRUM MONITORING MODULE

The spectrum monitoring program module performs the necessary functions to detect electromagnetic interferences (EMI) that significantly affect the range electromagnetic space.

The most efficient and positive method for providing EMI control is measurement of the frequency spectrum. The spectrum monitoring functions and the FCA equipments define an automatic frequency signal meter. The spectrum monitoring functions establish a frequency bandwidth. The adjustment range of the frequency bandwidth provides the spectrum monitoring module with considerable measurement flexibility. The bandwidth can be positioned to any specific frequency in the 5 kHz to 18 GHz frequency spectrum. The system can observe all signals in the selected frequency or can be directed to a specific bearing. The module can also be directed to accommodate a wide range of signal inputs.

The spectrum monitoring module is utilized to obtain the actual density of the frequency spectrum. The frequency measurements provide the following information:

A. Detection of Unscheduled Frequencies
B. Further Definition of Scheduled Signals Contained in the Data Base
C. Verification of Authenticity of Scheduled Frequencies
D. Definition of Signals
E. Spectrum Density
F. Spectrum Signal Voids
G. Direction of Hostile Signals
H. Directional Field Strength
I. Signal Signature Analysis

One of the basic advantages afforded by the frequency measurement is the availability of real-time information which can identify potential problem areas. The detection of unscheduled frequencies that interfere with range operations permits immediate action to be taken. The offended signal can be rescheduled and/or action can be taken against the offending transmitter. Notification can be given with respect to scheduled signals that are not operating within assigned allocations.

2.3.1 SPECTRUM SURVEILLANCE

Upon acknowledgement of the appropriate instructions, the surveillance module performs automatic RF spectrum surveillance within the limits specified in the input commands received from the decision module or the command master. The purpose of the spectrum surveillance module is to determine what transmitters are operating in a specified band. The system begins interrogating the receiver at f_1 and will proceed to f_2 by Δf steps, pausing at each discrete frequency long enough for the receiver to tune to the desired frequency and for the module to input the amplitude data.

2.3.2 SPECTRUM CHANGE

Spectrum data (signal level versus frequency data between f_1 and f_2) from one frequency scan is compared with data from the previous frequency scan. The system is capable of comparing data taken at each test frequency and produces an output when a change in the signal spectrum exceeds the threshold limit.

Upon acknowledgement of the input commands, the system begins interrogation of the receivers starting with f_1 and going through f_2 at Δf steps. The frequency signal level is compared with the frequency signal level of the previous scan. If the change is greater than the desired limit, the data is flagged, causing a printout to occur with the frequency, level of the measured signal, and time.

2.3.3 UNSCHEDULED RF EMANATION DETECTION

The system is capable of detecting and comparing all RF emanations against the selected RF schedule data base as designated by the system operator. Upon acknowledgement of the input commands, the system begins a spectrum surveillance. At each discrete frequency the system compares the receiver input to the data base. If there is an emission where none is scheduled, the system outputs the detected data.

2.3.4 RF SIGNAL ANALYSIS

The system is capable of performing the following RF signal measurements:

A. Frequency
B. Signal Level
C. Pulsewidth
D. PRF
E. Frequency Deviation

The system begins a spectrum surveillance pausing at each frequencv for a period long enough to make the preceeding measurements. This is done through interrogation of the signal analysis unit. The time delay is a function of the pulsewidth and PRF.

2.4 CALIBRATION MODULE

The data obtained by the FCA spectrum measurement equipments is utilized to identify and assist in eliminating unscheduled signals and to provide data which augments the data base content. System calibration insures the validity of system operation and provides the compensation necessary for system non-linearity. The measurement of known signal sources establishes the difference between the known signal and measurement signals. From a series of measurements, exact differences are established for signals based on power level, attenuation, signal path, frequency, etc. The compensation established a family of error curves which will be added to the measurement value of a signal. The fundamental objectives that are accomplished by the calibration procedures are delineated below:

A. Operability of Equipment
B. System Status
C. Signal Path Loss
D. Receiver Linearity
E. Signal Compression
F. Excessive Equipment Measurement Deviation
G. Data Confidence

2.4.1 AMPLITUDE/FREQUENCY CALIBRATION

The receiver system is amplitude calibrated by applying a known RF signal source to the input of the receiver. The FCA complex tunes the receiver to the frequency of the known signal source. The program then increases the frequency of the receiver and signal source in predefined steps. The system measures the signal level as the receiver is tuned to each step and the difference is stored in calibration tables for subsequent use by the spectrum surveillance programs. This is accomplished for each bandwidth of the receiver.

Both the receiver and signal source are synthesizer referenced. Thus, frequency calibration is provided by observing the calibration errors in the 1 kHz bandwidth. Abnormally large errors will indicate an equipment malfunction

2.5 FREQUENCY MANAGEMENT AND ANALYSIS MODULE

The frequency management and analysis module is provided to support the RF management function of frequency coordination. Frequency coordination is taken as the process of effecting arrangements and technical liaison for the purpose of minimizing electromagnetic interference through cooperative use of the radio frequency spectrum. This process includes allocation, assignment, and/or schedule of a frequency or band of frequencies. The program package establishes the compatibility of requested frequencies with existing activities.

The RF frequency management program operates in both real-time and non-real-time environments, either alone with the system executive, or with other in a real-time mode. The need for timely processing of frequency assignment requests is needed; therefore, the program allows the operator to specify only those calculations required for a particular application. Five analysis modules are utilized to provide an efficient RF frequency management package. These program modules are:

A. Individual Analysis
B. Rapid Cull
C. Comprehensive Cull
D. Schedule Analysis
E. Data Base Management

The basic individual analysis routines are organized to provide maximum user flexibility and equipment utilization within the context of the FCA objectives. These routines perform various signal analysis functions and form the basis for the FCA cull procedures.

The cull procedures support the coordination of the usage of the RF spectrum resources. The rapid cull procedures determine frequency schedule conflicts within minimal operational requirements. The comprehensive cull routines are capable of performing the cull procedures to various levels of accuracy dependent on the system operator's discretion and the allowable time for the procedure.

The schedule analysis programs determine an optimum frequency schedule from considerations of spectrum density, usage, interference culls, etc. This module requires extensive operator/machine communication to determine an optimized frequency schedule.

The data base management routines provide the capabilities for creating, merging, and updating the system data base. These procedures should be performed periodically to ensure the integrity of the FCA data base.

2.5.1 INDIVIDUAL ANALYSIS MODULE

The real-time surveillance capabilities of the FCA complex are complemented by off-line analysis capabilities to provide a realistic frequency management and control capability. The FCA analysis capability is predicated on three fundamental factors: (1) the determination of the effects of receiver-transmitter pair interference based on existing, planned and detected unscheduled transmitters, (2) the utilization of the FCA detection and display capability as the fundamental analysis tool, (3) analyses based on detected frequency environment rather than generalized analyses programs utilizing typical system parameters.

The general concept which supports the FCA analysis requirement is estimating frequency schedule compatibility based on available data; therefore, significant emphasis is placed on data fidelity rather than manipulation of expectant or typical data. This data is then utilized to define existing incompatibilities and develop subsequent solutions.

The FCA analysis capability is comprised of several different analyses that are communitive with each other. The communitive nature of each analysis requires the results of one analysis be used by other analyses such that the utilization of a subset of analyses places emphasis on a particular problem.

3.2 COMMAND MASTER CONFIGURATION

The FCA command master performs three fundamental operations. The command master controls or initiates control of the FCA complex. This control includes the transfer of commands to the remote sites, the reception of data from the remote sites, and the control of external command requests. The command master also provides for data storage, the display of acquired data, and the creation and maintenance of the system historical data base. Finally, the command master performs the analysis procedures required for control and management of the frequency spectrum. An FCA command master site configured to control and maintain one remote site includes the following equipment:

a. Computer with 56 K of Memory
b. Two Disc Units with 5 M Byte Capacity Each
c. Two 9-Track Magnetic Tape Units
d. Three Spectrum Displays
e. X-Y Recorder
f. Card Reader
g. Line Printer
h. Teleprinter
i. High Speed Paper Tape Unit
j. CRT/Keyboard with Alert Indicators
k. One Full Duplex Modem Controller
l. GFE Dial Assembly Terminal

One disc and magnetic tape unit is required for each additional remote site added to the FCA complex. One modem controller is also required for each additional remote site added to the FCA complex. To implement additional remote site functions into the FCA command master control, a minimum of one modem controller and additional data storage devices (disc unit and/or magnetic tape units) will be required.

Coordinating the FCA command master responsibilities with the available hardware results in the equipment being structured according to their primary functions within the overall system objective. This structuring does not limit the functions of a particular device, but it does define its primary responsibility. The hardware structure is delineated in the following paragraphs. The system computer is an integral part of each group.

3.2.1 COMPUTER GROUP

A GTE-IS 1000 computer is used at both the command master and remote sites to provide the operator complete control of the FCA complex. The computer employs parallel 16-bit organization with 16 programmable registers, autoload, real-time clock, a large instruction set with a minimum of 96 instructions, and a 750 nanosecond memory cycle. Modular construction with integral power supplies, housed in rack-mountable chassis, is used to simplify system configuration, field expansion, and serviceability.

A priority-interrupt system is used with a versatile I/O instruction set and hardware controlled direct memory access. All I/O functions are handled via the I/O bus. This bus interfaces with the peripheral controllers to drive the controllers and to carry data, control, and interrupt signals. A I/O bus buffer is provided between the computer and computer controllers.

A power failure monitor and automatic restart capability are provided. This feature provides the processor an interrupt when power failure occurs. This interrupt will cause the program to bring the processor to a normal halt condition, thereby insuring correct program operation when power is restored. If automatic restart is enabled, the program restarts when power is restored.

An instruction trap capability is provided. This feature provides for the detection of instructions and addressing modes that are not hardware implemented. Detection of such an instruction results in an interrupt to a memory location.

A direct memory access capability is provided. This feature provides for the transfer of data between the I/O bus and memory, bypassing all CPU registers. The transfers are accomplished on a memory cycle-stealing basis. Refer to table 3-1 for processor specifications.

A hardware multiply and divide is provided. Multiplication logic allows a 16-bit x 16-bit multiplication in two's complement-binary format, resulting in a 31-bit product. Divide logic allows a 31-bit x 16-bit division, resulting in a 16-bit quotient with a 15-bit remainder.

All peripheral controllers are located in the computer controller chassis and use the computer integral power supply.

3.2.2 DATA STORAGE GROUP

The data storage group consists of equipment utilized to store large quantities of system data or input system data and/or parameters into the system computer. The data group equipment includes a disc, magnetic tape transport, high speed paper tape reader, high speed paper tape punch, and a card reader. Refer to table 3-2 for a list of data group equipment and figure 3-1 for a data group block diagram.

Table 3-1 Tempo II Computer Specifications

FUNCTIONAL	Arithmetic:	Parallel, binary, fixed-point, two's complement. Hardware multiply/divide.
	Word Length Instructions: Data:	 16 or 32 bits 16 bits
	Hardware Registers:	16 general purpose, 22 total.
	Interrupt Priority Levels:	8
	Addressing Modes:	Direct, indirect, indexed, indexed/indirect, indirect/indexed, indexed/indirect/indexed, immediate and relative.
	Instruction Set:	14 load and store 14 arithmetic 9 logical 13 register 19 shift 15 branch 5 control 5 I/O 2 special
	Memory Type:	Ferrite core, direct access.
	Memory Speed:	750 ns/cycle (read/restore).
	Memory Size:	8192-word increments.
	Words Directly Addressable:	65,536
	I/O Bus:	Buffer driver.
	I/O Interface Rate:	Up to 86,000 words/second (program dependent).
	DMA Rate:	Up to 1.1 million words per second.
	IOP	Enables 4 peripherals to use DMA.
ELEC-TRICAL	Circuitry:	Solid state, including TTL, DTL and MSI integrated circuits and silicon semiconductors.
	Power:	115V AC +10%, 60 Hz, 8A, maximum integral supply.
MECHANICAL	Chassis, Dimensions: Weight: Capacity:	7"H x 9"W x 22"D. Less than 75 pounds. Positions for 8 boards.
	CPU Module	Program Flags Byte-Oriented Instructions Automatic Program Loading Using the Read-Only Memory Direct Memory Access Power Fail/Restart Interrupt Mask Instruction Trap Control Panel Power Panel Real-Time Clock
	Program Load Read-Only Memory Type: Capacity:	 Solid state 16-bit word length; 128 words (not part of main memory).

Refer to vendor manual, Tempo II, for more information.

Table 3-2 **Data Group Equipment**

Item	Manufacturer	Model Number	Quantity
Magnetic Tape Unit	Pertec	6840-9	2
Disc	Caelus	203-2	2
Paper Tape Reader	Digitronics	2540 EP	1
Paper Tape Punch	Talley	1200	1
Card Reader	United Business	500	1

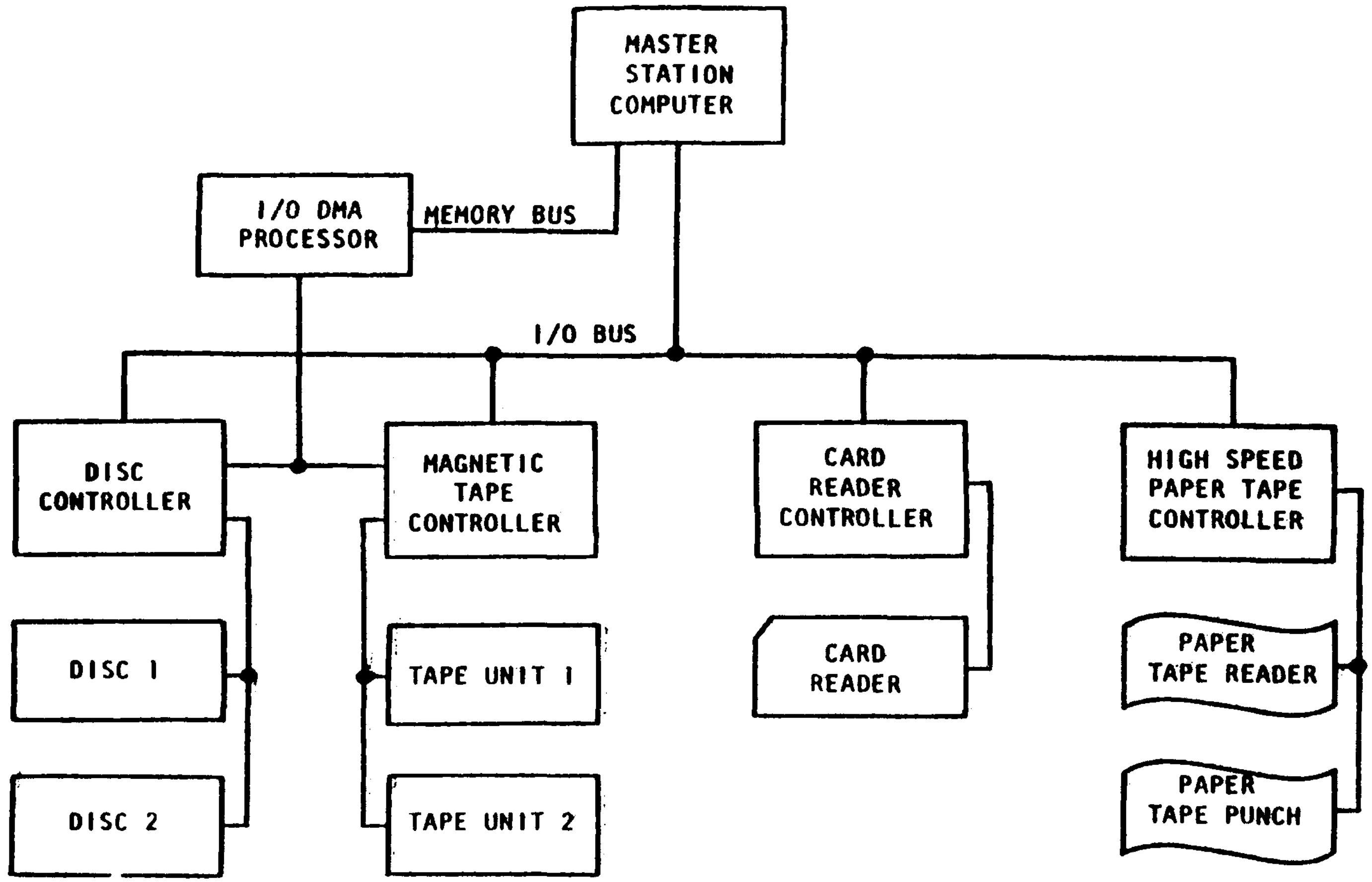


Figure 3-1 Data Storage Group

SECTION 4.0

REMOTE SITE SYSTEM

4.1 REMOTE SITE EQUIPMENT GROUPS

Several groups of equipment are utilized to fulfill the FCA system requirements. This equipment is divided into functional FCA modular elements. As with the command master site, the site computer is an integral part of all hardware groups. A minimal FCA remote site configuration includes the following equipment:

A. Computer with 32K of Memory
B. Disc Unit with 5M Byte Capacity
C. Keyboard/CRT
D. Telepage Printer
E. High Speed Paper Tape Reader
F. CRT Display
G. Microwave Noise Sources
H. 30 MHz - 1000 MHz Noise Source
I. 1 MHz - 10 MHz Frequency Synthesizer
J. 5 kHz - 1 MHz Frequency Synthesizer
K. Microwattmeter
L. Millivoltmeter
M. RF Patch Panel
N. Status Panel
O. 5 kHz - 1000 MHz Receiver
P. 1 GHz - 18 GHz Microwave Tuners
Q. Microwave Frequency Counter
R. Signal Analysis Unit
S. Antennas (Omni and Directional)
T. RF Switches
U. Attenuators
V. Preamplifiers
W. Antenna Pedestals

4.1.1 SYSTEM COMPUTER

The FCA control group consists of a general purpose computer and equipment controllers. A controller is provided to interface each FCA module with the system computer. Table 4-1 delineates the basic system computer characteristics.

4.1.2 DECISION GROUP

The decision group is used by the site operator to locally control a remote FCA site. The decision group consists of a keyboard, CRT, and alert panel, status panel, and a control panel. System commands are entered locally by the site operator from the keyboard. System data, operational status, and operator commands and interrogations are printed out on the telepage printer. Directional antenna positions and attenuation levels are displayed on the antenna status panel. Controls are provided to permit attenuation levels and pedestal positions to be controlled. When the site is in the remote mode, decision commands and responses are transferred to and from the FCA command master via the modem controller.

4.1.2.1 CRT/KEYBOARD CONTROLLER

Refer to paragraph 3.2.3.1 for a detailed discussion of the CRT/Keyboard and controller. Figure 4-1 illustrates the keyboard codes and the remote site keyboard is shown in Figure 4-2.

4.1.2.2 OPERATORS STATUS PANEL

The status panel consists of a functional flow block diagram of the RF and pedestal system from the antennas to the SCI receiver. The panel displays in real-time, by means of LEDs, digital displays, and LED switch matrices, the following:

A. Antenna in Use
B. RF Path(s) in Use
C. Attenuation Value in Each RF Path
D. RF Tuner in Use
E. System Calibration Device in Use

4.2 REMOTE SITE CAPABILITIES

The fundamental objective of the FCA remote site is to extend the frequency monitoring and surveillance range of the FCA complex. The remote sites contain the software to perform the frequency surveillance functions. The accuracy of the frequency monitoring and surveillance data depends on the reliability of the system equipment. Therefore, equipment calibration is of paramount importance for validity of system operation and for the compensation for system non-linearity. The following functions are the basis for remote site system operation:

A. Control of Attenuator Pad Settings
B. Control of Receiver/Tuner Frequency Settings
C. Control of Antenna Switching Selection and Antenna Bearings
D. Control Input of Digitized Signal Strength, Frequeney and Signal Type

The surveillance and calibration functions are capable of local or remote operation. Under local control the site operator manually supplies all input parameters for the required functions. The site operator controls all phases of the remote site operation until a control command is received from the command master. The command master provides site control commands under the remote operational mode. The command master operator supplies a job scenario to define the remote site operation. Both in the local and remote modes, the controlling operator is capable of dynamically reconfiguring system operation by using the decision module functions.

The remote site also provides a backup to some of the command master analysis functions. These functions are limited due to the I/O capabilities of the remote site and are not used unless the command master is incapable of performing the functions. The remote site analysis functions are performed only in the local mode.

Diagnostics functions are available to determine the operability of the remote site equipment. The diagnostic programs provide the site operator the means to determine the accuracy of each equipment item. The diagnostics also serve as an aid in isolating equipment malfunctions. The diagnostics functions are performed in the local mode under direct operator control.

4.2.1 DATA INPUT EQUIPMENT

The disc unit is a high speed device whose data transfers to computer memory are time-shared with the CPU on a cycle stealing basis. The paper tape controller controls the transfer of paper tape data from the high speed paper tape reader.

4.2.2 OPERATOR EQUIPMENT

The FCA system is structured to respond to operational requests. This structure permits complete operational use of the FCA systems by a single operator. Commands are entered from the keyboard. Command selection includes special function keys and a complement of alphanumeric keys. Simplification of command entry and operator assistance is obtained by the CRT system alarm panel and system status panel. The CRT works with the keyboard to provide command selection alternatives, system responses, and supplemental system information. The system status panel displays the current system configuration and specific system values, such as direction and attenuation. The system alarm panel displays system irregularities and critical situations. Associated with the system status panel is a system control panel. The system control panel is a maintenance aid which permits manual control of antenna direction and attenuation selection. A separate controller is used for the CRT and keyboard. The system alarm panel is a part of the CRT; therefore, the CRT controller is used to transfer data to the system alarm panel. The system status panel is interfaced with several system signals. The system configuration display is obtained by monitoring switching commands stored in the switch controller. The display of attenuation selections is obtained by monitoring the attenuation commands or attenuator status lines available at the attenuator controllers. The direction of the positioner's azimuth and elevation axes is obtained directly from the optical shaft encoders in the positioners. Polarization selection and limit switch indications are obtained from the polarization and position controllers.

4.4 SPECTRUM MONITORING RECEIVER GROUP

The spectrum monitoring group includes the hardware necessary to perform the primary function of the FCA complex, frequency monitoring and surveillance. Various combinations of receiving equipment, antennas, and antenna positioning equipment are required to perform these frequency surveillance functions. RF switches are necessary to select the correct hardware configuration to monitor a specified frequency or frequency band in the 5 kHz to 18 GHz frequency spectrum.

4.4.1 RECEIVING EQUIPMENT

Receiving equipment is supplied to cover the frequency range of 5 kHz to 18 GHz. This equipment is illustrated in Figure 4-11. It is capable of being operated in the remote mode by the FCA command master or by the FCA remote site operating in the local mode.

The receiver is used to monitor any specified frequency in the 5 kHz to 1 GHz range. When operating in the microwave region, the receiver is used in conjunction with the microwave tuners to monitor the specified frequency.

The frequency counter is used in a closed loop frequency mode with the system computer and microwave tuners to provide frequency accuracy in the microwave bands. The digital-analog converter is used to convert digital commands from the system programmer to analog tuning commands for the tuners.

The signal processor performs further signal processing on video signals from the receiver.

4.4.1.1 5 kHz TO 1 GHz RECEIVER AND CONTROLLER

4.4.1.1.1 5 kHz TO 1 GHz RECEIVER

The 5 kHz to 1 GHz receiver is the heart of the RF system equipment. All RF signals detected are routed to the receiver where it will process these signals according to instructions from the system computer. The receiver is completely programmable, except for audio output controls and is manually

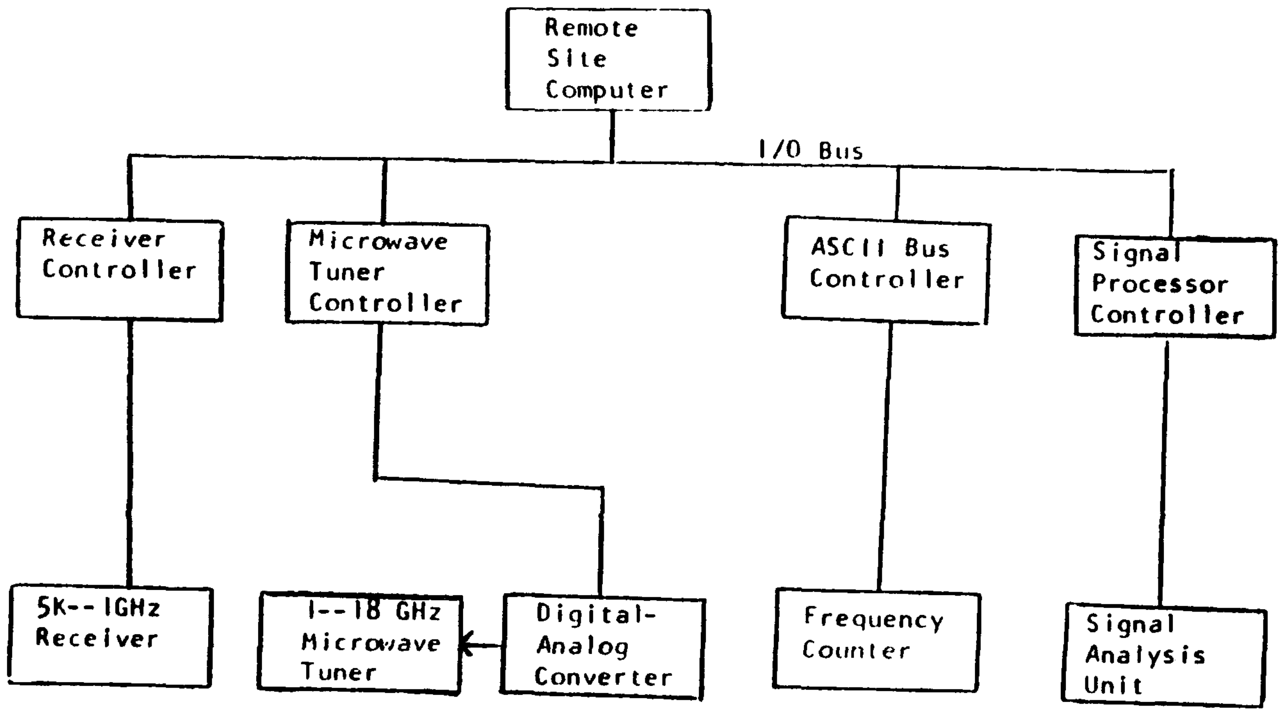


Figure 4-11 Spectrum Monitoring Receiving Group

4.6 SENSOR GROUP

Refer to Figure 4-13 for a block diagram of the sensor group.

4.6.1 ANTENNAS

The sensor group consists of all system antennas that are required to provide omnidirectional and directional frequency coverage from 5 kHz to 18 GHz. The antennas also provide vertical and horizontal polarization coverage from 30 MHz to 18 GHz. The antenna equipment general characteristics are delineated in Table 4-17. Broadband antennas are used to minimize the number of antennas required to cover the frequency range.

4.6.1.1 ANTENNA CHARACTERISTICS

The microwave antennas consist of two omnis (1-12.4 GHz, 12.4-18 GHz), a standard gain horn (12.4-18 GHz) and two log periodic feeds (1-12.4 GHz), one feeding a 6-foot dish, and one back-to-back with the primary feed pointed away from the dish to obtain broad beamwidth characteristics for acquisition. Refer to Tables 4-18 through 4-21.

The 5 kHz to 1 GHz antennas consist of a crossed log periodic (30 MHz-1 GHz), three omnis (5 kHz-30 MHz, 30 MHz-250 MHz, 250-1000 MHz) and two loops (5 kHz-2 MHz and 2-30 MHz). Refer to Tables 4-22 through 4-27.

4.6.2 RF SWITCHES AND CONTROLLER

4.6.2.1 RF SWITCHES

The RF switches perform signal routing and selection in the various subsystems. There are three basic categories of switches used in the system. They are:

A. Mechanical switches for antenna and calibration selection in the 1-18 GHz frequency range, where low insertion loss is the decisive criterion.

B. Solid-state switches for band, L.O., and IF select in the 1-18 GHz frequency range, where speed of operation is the decisive criterion.

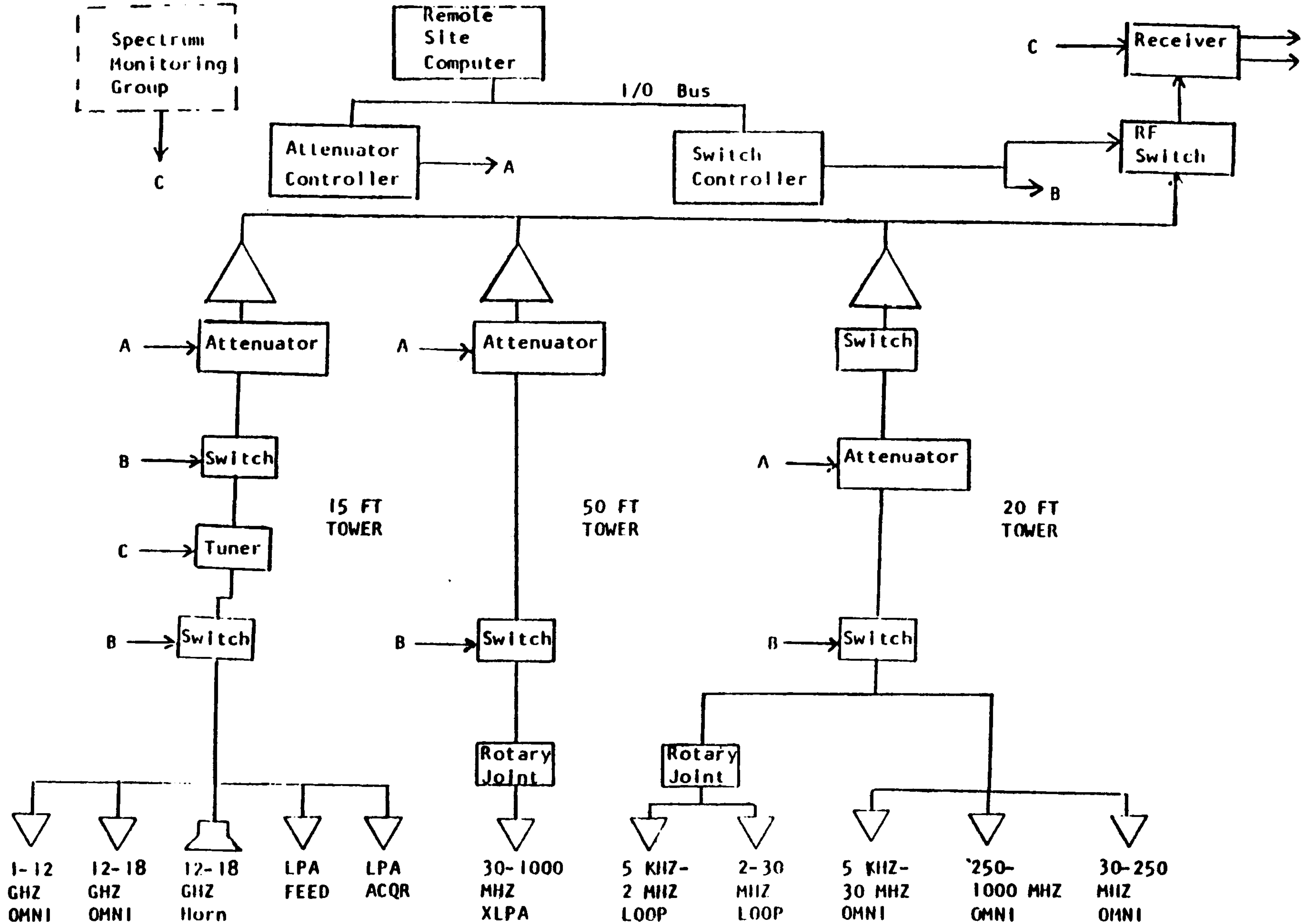


Figure 4-13 Sensor Group

Table 4-17 Antenna Characteristics

Frequency Range	Type	Pattern	Manufacturer	Model No.
12-18 GHz	Conical Spiral	Omni	TECOM	201023
12-18 GHz	Horn	Directional	Scientific Atlanta	12-12
1-12.4 GHz	6 ft. Dish & LPA Feed	Directional	Scientific Atlanta	22-6 Dish & Series 27 LPA
1-12.4 GHz	Log Periodic	Directional	Scientific Atlanta	Series 27 LPA
1-12.4 GHz	Conical Spiral	Omni	TECOM	201016
30-1000 MHz	Crossed Log Periodic	Directional	TECOM	201034
250-1000 MHz	Conical Spiral	Omni	TECOM	201015
30-250 MHz	Log Periodic Monopole	Omni	TECOM	201028
5 kHz-30 MHz	Active Monopole	Omni	Antenna Research	AVW-2/A
2-30 MHz	Active Loop	Directional	Hermies Electronics	SLEHF
5 kHz-2 MHz	Active Loop	Directional	Antenna Research	BBH-160/A

The antenna subsystem is designed to survive winds of at least 100mph and to operate at 40mph with no ice and are weatherproofed for constant exposure in a tropical coastal environment.

Table 4-18 Antenna Specifications, 1-12.4 GHz Omni (TECOM 201016)

Frequency Range:	1 to 12.4 GHz.
VSWR:	Maximum: 2.0:1; Average: 1.5:1.
Polarization:	Circular.
Impedance:	50 ohms.
Directive Gain:	0 dBi.
Azimuth Pattern:	Omnidirectional ± 3 dB.
Connector:	N, female.
Environmental:	125mph wind, no ice, tropical coastal.

Table 4-19 Antenna Specifications, 1-12.4 GHz, LPA Feed (6' Dish), LPA Acquisition (Scientific Atlanta Series 27)

	Feed (6' Dish)	Acquisition
Frequency Range:	1-12.4 GHz	1-12.4 GHz
VSWR:	2.5:1	2.5:1 maximum.
Impedance:	50 ohms.	50 ohms.
Gain:	19 40	7 dBi min. @ 1 GHz. 7 dBi min. @ 12.4 GHz.
Polarization:	Linear Vertical or horizontal selected by rotation of polarization positioner.	Linear
Environmental:	100mph wind, no ice, tropical coastal.	

Table 4-20 Antenna Specifications, 12-18 GHz, Omni (TECOM 201023)

Frequency Range:	12-18 GHz
VSWR:	2.0:1 maximum.
Directive Gain:	0 dBI.
Polarization:	Linear vertical.
Impedance:	50 ohms.
Azimuth Pattern:	Omnidirectional ± 3 dB.
Connector:	N, female.

Table 4-21 Antenna Specifications, 12-18 GHz, Standard Gain Horn (Scientific Atlanta 12-12)

Frequency Range:	12.4-18 GHz
Nominal Gain:	24.7 dBi @ 16 GHz.
Nominal Beamwidth:	E-Plane: 9°; H-Plane: 10°.
VSWR:	1.5:1 maximum.
Polarization:	Linear, vertical or horizontal selected by rotation.
Connector:	Waveguide.

Table 4-22 Antenna Specifications, VHF/UHF, Cross Log Periodic (TECOM 301034)

Frequency Range:	30-1000 MHz
VSWR:	2.25:1 maximum; 1.6:1 typical.
Gain:	7 dBi, minimum.
Polarization:	Dual linear (selectable).
E-Plane Beamwidth:	65°
H-Plane Beamwidth:	110°
Front-to-Back Ratio:	20 dB.
Isolation:	20 dB.
Power:	1kW peak, 25W average.
Input Impedance:	50 ohms - each polarization.
Input Connector:	N, female - each polarization.
Antenna Weight:	150 lb.
Mount Weight:	15 lb.
Material:	Aluminum and fiberglass.
Hardware:	Stainless steel.
Environmental:	125mph no ice; 75mph 1/4" ice; 50mph 1/2" ice. Tropical coastal.

Table 4-23 Antenna Specifications, VLF/HF Omni (Antenna Research AVW-21B)

Frequency Range:	5 kHz to 30 MHz.
Threshold Sensitivities:	**Better than 0.05μV/meter above 300 kHz (0 dB S/N and 1 kHz bandwidth). At frequencies lower than 300 kHz, sensitivity is degraded at the rate of approximately 17 dB per decade.**
Antenna Factor:	8 dB average (μV/m relative to μV output across a 50 ohm load).
Output Impedance:	50 ohms nominal.
Effective Height:	Approximately 0.4 meter over frequency range.
Output Connector:	TNC, female on antenna and TNC female at receiver output terminal on power supply.
Power:	A remote power supply with decoupling network places +12V on the center conductor of the RF coaxial cable to the power unit. This power supply requires 105-130V AC, 50-60 Hz, single phase and consumes about 10 watts from the line.
Wind and Ice:	The antenna will withstand winds in excess of 150 mph without ice or 80mph with 1'' radial ice.
Salt Spray:	The antenna is designed to withstand continuous salt spray with little degradation in overall performance.
Height:	Approximately 72'' overall.
Weight:	Approximately 30 lb.
Material:	Aluminum and delrin.

Table 4-24 Antenna Specifications, VHF Omni (TECOM 201028)

Frequency Range:	30-250 MHz.
Omni Pattern:	+0.5 dB from omni.
Gain:	0 dBi.
Impedance:	50 ohms.
VSWR:	5.0:1 maximum.
Weight:	35 lb., maximum.
Connector:	N, female.

Table 4-25 Antenna Specifications. UHF Omni (TECOM 201015)

Frequency Range:	250-1000 MHz
Vertical Plane Bandwidth:	55°
VSWR:	Maximum: 1.75:1; Average: 1.3:1.
Polarization:	Circular.
Directing:	0 dBi.
Impedance:	50 ohms.
Power Handling:	Peak: 1kW; Average: 250W.
Deviation from Omni:	± 3 dB.
Connector:	N, female.

Table 4-26 Antenna Specifications, VLF Loop (Antenna Research BBH-160/A-S1)

Frequency Range:	5 kHz to 2 MHz.
Polarization:	Vertical.
Directivity:	Bidirectional in H-plane. Omnidirectional in E-plane.
Directive Gain:	4.5 dBi, minimum.
Null Depth:	20 dB, minimum.
EM Sensitivity:	Magnetic field.
Impedance:	50 ohms.
Power Requirement:	Remote power supply with decoupling network will operate on 110V, 50-60 Hz, 10 watts and will supply 12V DC to antenna through the RF coaxial cable.
Output Connector:	Type TNC.
Circuitry:	Solid state.
Decoupling Unit:	The decoupling unit will remove the +12V DC power placed on the RF line by the remote power supply's decoupling network and provide separate power and RF paths. The unit will have TNC connectors which will be color coded or otherwise identified to insure connection to proper connector. The unit shall be completely sealed, suitable for use in tropical coastal environment and shall be mounted to the base plate of the antenna.

Table 4-27 **Antenna Specifications, HF, Loop (Hermes SLEHF)**

Frequency Range:	2-32 MHz.
Polarization:	Vertical.
Directive Gain:	4.7 dBi, minimum.
Directional Characteristics:	Azimuth: Figure eight with nulls on loop axis. Elevation: Omnidirectional in the elevation plane containing the loop.
Output Impedance:	50 ohms.
Loop Diameter:	1 meter.
Weight:	10 lb., approximately.
Preamplifier Power Requirement:	100ma at +12V DC.
Preamplifier MTBF:	1/4 million hours (at +70°C).
Environmental Temperature Range:	-40°C to +70°C.
Wind Loading:	200mph (no ice); 100mph (1" radial ice).
Power Supply and Multicoupler:	DC power is fed to the loop preamplifier via the coaxial cable connecting the array to the receiver.

C. Mechanical switches for antenna and calibration selection in the 5 kHz to 1 GHz frequency range where reliability and the frequency range are the decisive criterion.

All switching is accomplished only by the system computer for two fundamental reasons. First, system scan rates require multiple reconfigured paths each second. Secondly, the several possible operating modes of the FCA system require multiple tier switching and accurate switch position selection for proper system operation, thereby obviating a reasonable operator interface.

The criteria for selecting the switch type for each switch location is based on repetity of utilization. If a switch cycle is required during each receiver scan during normal system operation, a solid state switch is utilized. Mechanical switches were selected wherever a switch cycle was based on operating mode changes; i.e., surveillance to calibration, directional to omnidirectional frequency coverage, etc.

Table 4-28 delineates each switch in a signal path, the type of switch number of poles, rated number of operations, manufacturer and model number. Tables 4-28 through 4-40 give the characteristics of each switch. Refer to the vendor's manuals for more detailed information.

4.6.2.2 RF SWITCH CONTROLLER

The RF switch controller provides the interface between the computer and the system RF signal path switches. The controller provides the switch drive and storage. Switch position indication is distributed to the decision module.

4.6.2.2.1 GENERAL CHARACTERISTICS

The system signal path switches comprise solid-state and mechanical solenoid actuated switches. Therefore, the general characteristics of the switches are divided into number of poles and switching time required.

Table 4-28 RF Switch Characteristics

Frequency Band	Switch Purpose (Primary)	Type	Rated Number of Operations	Manufacturer	Model Number
1-18 GHz	Antenna Select	SP3T/Mech.	1,000,000	TRANSCO	143C70100
1-12.4 GHz	Antenna Select	SPDT/Mech.	1,000,000	TRANSCO	920C01700
1-12.4 GHz	Antenna Select	SP3T/Mech.	1,000,000	TRANSCO	143C70100
1-18 GHz	L.O. Select	SPDT/Solid State	N/A	Gen. Microwave	M870
1-12 GHz	Preamplifier Select Tuner Select	SPDT/Solid State	N/A	Gen. Microwave	AM870
1-18 GHz	L.O. Select	SP4T/Solid State	N/A	Gen. Microwave	M871
160 MHz	IF Select	SP5T/Solid State	N/A	DIACO	10006585-1-160
5 kHz-1000 MHz	Polarization Select	SPDT/Mech.	50,000,000	Fifth Dimension	1502
5 kHz-1000 MHz	Antenna Select	SP3T/Mech.	50,000,000	Fifth Dimension	1503
5 kHz-30 MHz	Antenna Select	SP4T/Mech.	50,000,000	Fifth Dimension	1504
5 kHz-1000 MHz	Receiver Input Select	SP5T/Mech.	50,000,000	Fifth Dimension	1505
5 kHz-1000 MHz	Calibration Select	4-Port π Mech.	50,000,000	Fifth Dimension	1105

4.6.2.4 PREAMPLIFIERS

Preamplifiers are supplied as part of the FCA system, throughout the 30 MHz - 18 GHz frequency range. Thus, the preamplifiers are located as near the antennas as possible. Refer to Tables 4-45 through 4-49. Active antennas with integral preamps are supplied for the 5 kHz to 30 MHz frequency range. The preamplifier group is used to decrease the noise figure of the microwave tuners and selected signal paths. The microwave tuner preamplifiers are located in close proximity to the tuners and respective antennas in order to minimize signal loss. Preamplifiers used in a signal path above 30 MHz are also colocated with the respective antenna. In general, the location of the preamplifier was selected to service numerous signal paths and to minimize the signal path noise figure.

Table 4-45 delineates the preamplifier used for different frequency bands, the manufacturer, model number, gain, and noise figure specification in the respective band.

TABLE 4-45 PREAMPLIFIER CHARACTERISTICS

Frequency Band	Type	Gain Typical	Noise Figure Typical	Manufacturer	Mode. No.
12.0-18 GHz	TWT	30 dB	8.0 dB	Watkins-Johnson	WJ-371
4-12.0 GHz	TWT	32 dB		Watkins-Johnson	WJ-303
4-8 GHz Band			5.0 dB		
8-12 GHz Band			7.5 dB		
1-4 GHz	Solid State	28 dB		Watkins-Johnson	WJ-600
1-2 GHz Band			5.0 dB		
2-4 GHz Band			6.0 dB		
30-1000 MHz	Solid State	26 dB	5.0 dB	Avantek	AWL-12

TABLE 4-46 PREAMPLIFIER, 0.1-1200 MHz
AVANTEK AWL-1200

Frequency Range:	0.1-1200 MHz
Noise Figure:	6 dB Maximum; 5 dB Average
Gain:	25 dB Minimum; 26 dB Typical Minimum
Gain Flatness:	$\pm$1.5 dB Minimum; $\pm$1.0 dB Typical
Power Output for 1 dB Gain Compression:	+5 dB Minimum; +7 dBm Average
Third Order Intercept Point:	+15 dBm
VSWR Input:	2.0 Maximum
VSWR Output:	2.0 Maximum
Input Power:	115 Vac
Preamplifier Power:	Integral Power Supply
Connectors:	TNC Female

TABLE 4-47 PREAMPLIFIER, 1-4 GHz
WATKINS-JOHNSON WJ 6007

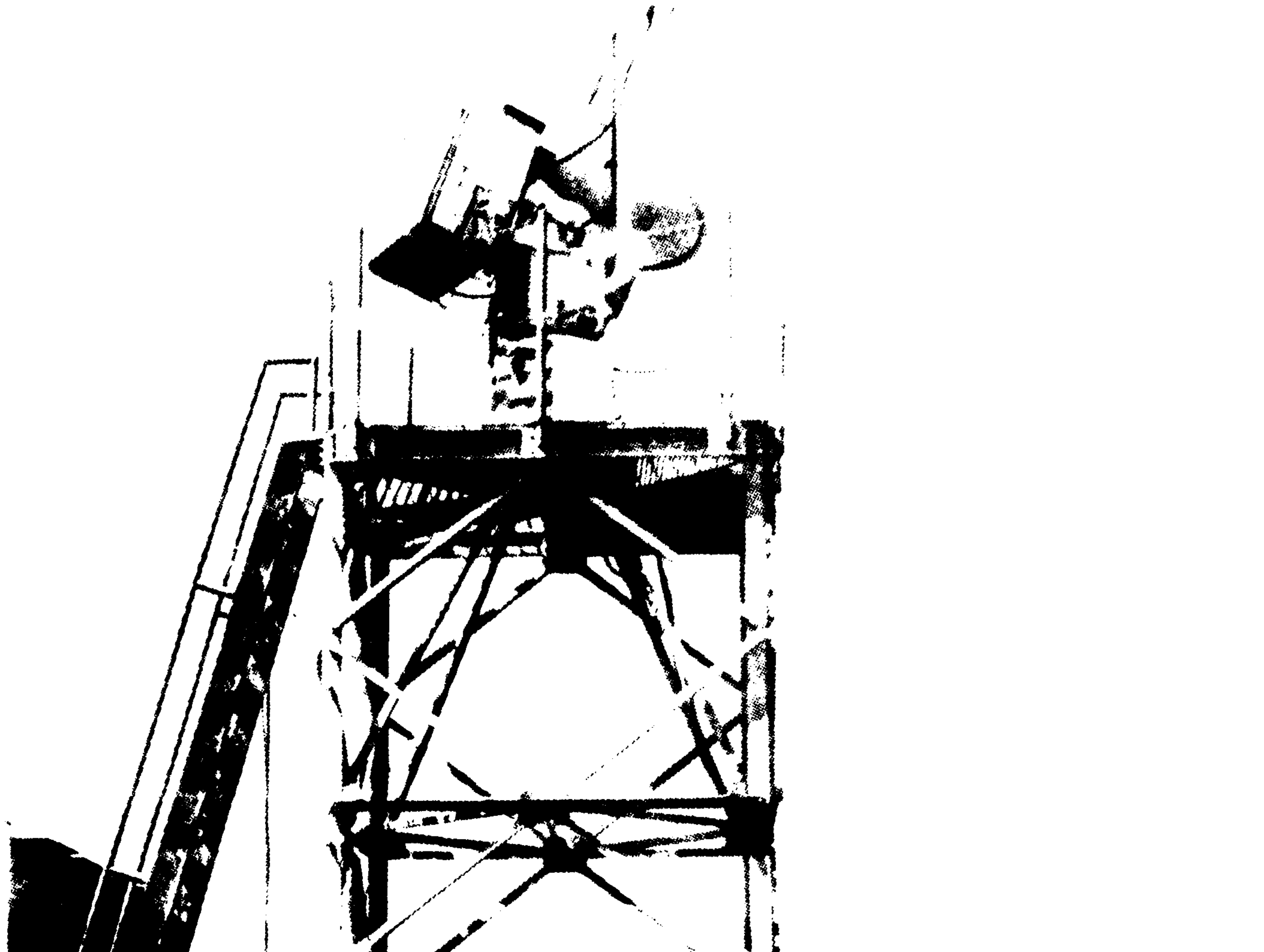
Frequency Range:	1-2 GHz	2-4 GHz
Noise Figure:	6.5 dB, Maximum	7.5 dB Maximum
Gain, Small Signal:	25 dB, Minimum	25 dB, Minimum
VSWR, Input, Output:	2.5:1 Maximum	2.5:1 Maximum
Power Output for 1 dB Gain Compression:	+5 dBm Minimum	+5 dBm Minimum
Impedance, Input, Output:	50 ohms	50 ohms
Input Power:	115 ± 10 Vac	115 ± 10 Vac
Connectors:	SMA Female	SMA Female

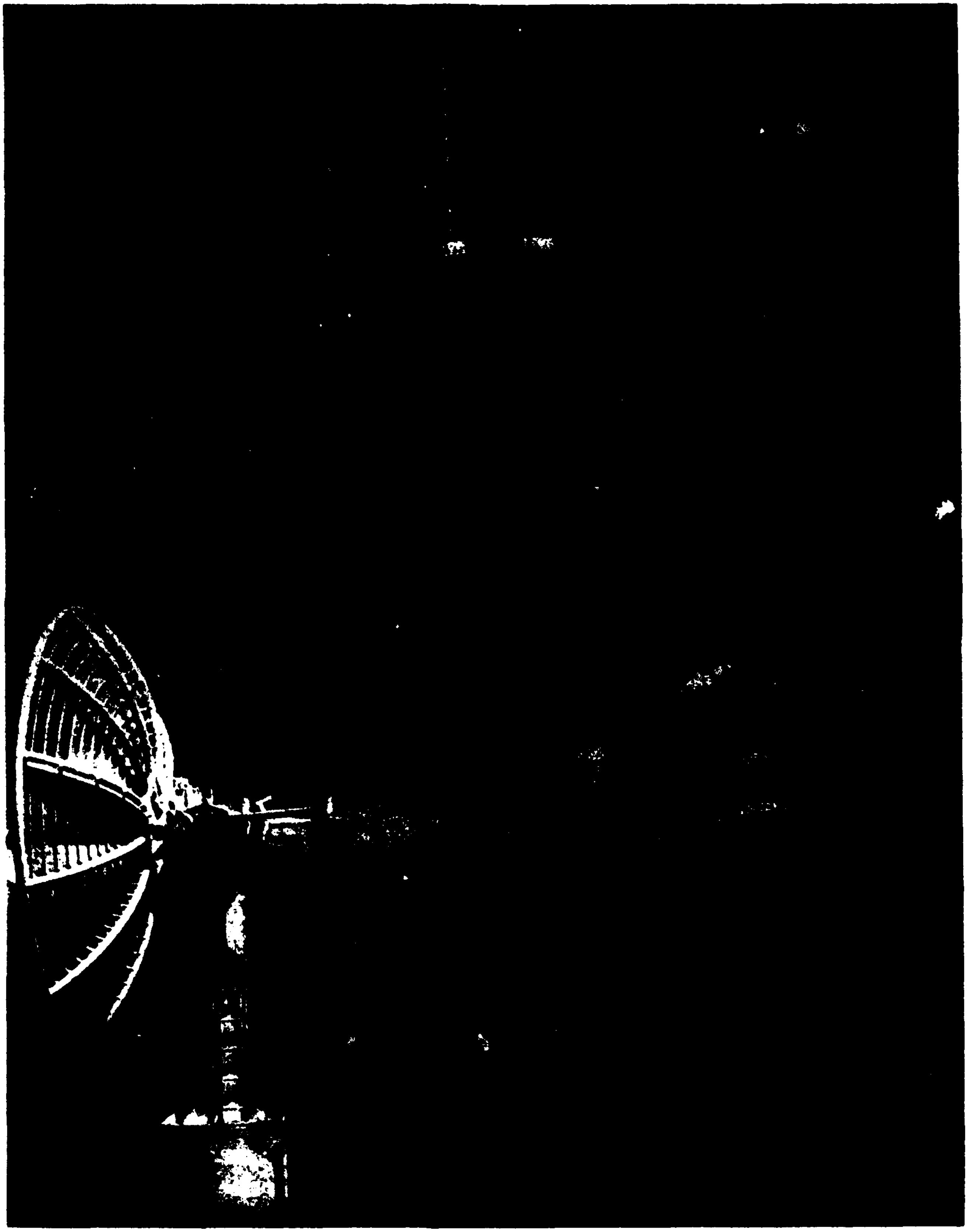
TABLE 4-48 PREAMPLIFIER, 4-12.4 GHz
WATKINS-JOHNSON WJ 3033

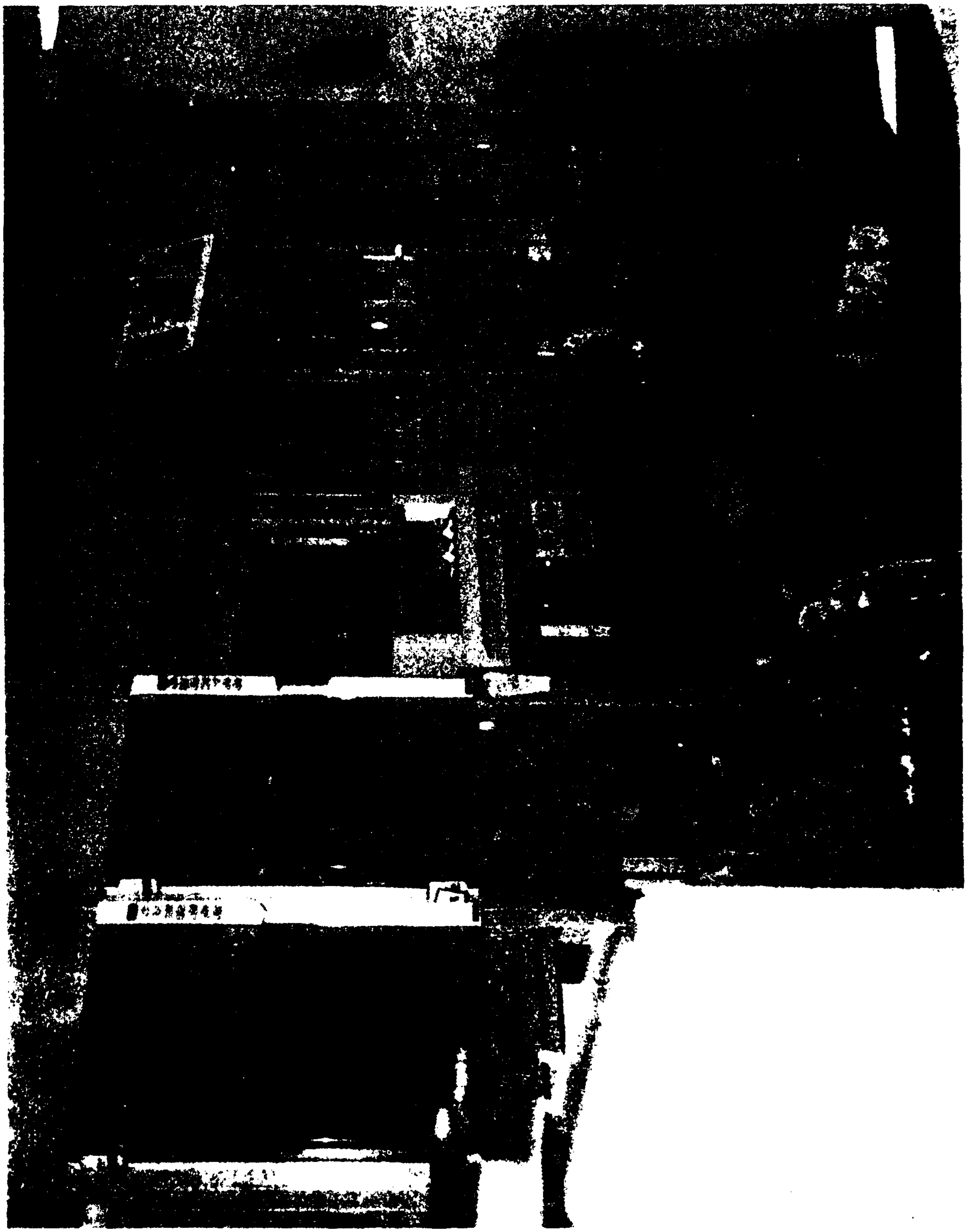
Frequency Range:	4-8 GHz	8-12 GHz
Noise Figure:	8.0 dB Maximum	8.5 dB Maximum
Gain, Small Signal:	30 dB	30 dB
VSWR, Input, Output:	2.5:1 Maximum	2.5:1 Maximum
Power Input:	115 ± 10 Vac	115 ± 10 vac
Connectors:	SMA Female	SMA Female

TABLE 4-49 PREAMPLIFIER 12.4-18 GHz
WATKINS-JOHNSON WJ-371

Frequency Range:	12-18 GHz
Noise Figure:	9.0 dB Maximum
Gain, Small Signal:	25 dB Minimum
VSWR, Input and Output:	2:1 Maximum
Input Power:	115 ± 10 Vac
Connectors:	SMA Female







APPENDIX C

EASTERN SPACE AND MISSILE CENTER

PATRICK AIR FORCE BASE, FLORIDA

EASTERN SPACE AND MISSLE CENTER

FREQUENCY CONTROL AND ANALYSIS SECTION

RF SURVEILLANCE TECHNIQUES

General

The Frequency Control and Analysis (FCA) section functions as the operations support arm of the Eastern Space and Missle Center (ESMC) Frequency Management office and provides a full compliment of RF surveillance services for all range users. Figure 1A is a functional block diagram of the organization structure.

The FCA section uses a wide variety of electronic measurement equipment configured in one central fixed station, referred to as the FCA console, and two identically instrumented mobile vans to perform most RF surveillance functions. In addition, three remote stations provide 24 hour monitoring of the flight termination frequency. Equipment configuration block diagrams of the FCA console and mobile vans are shown in figure 1 and 2 respectively.

An airborne direction finding system, carried on board a range support helicopter, is used for the rapid location of RFI sources when the use of ground based measurement techniques are not appropriate. This system is currently used for the flight termination frequency spectrum only.

A third vehicle, referred to as the quick response vehicle (QRV), can be instrumented on short notice and used for RF surveillance operations in areas not readily accessible by the two larger mobile vans.

RF surveillance services provided are divided into the following categories:

1. RFI investigations

2. Launch support

   A. Launch vehicle coverage

   B. News media coverage

3. Radio Area Sensor System (RASS)

4. Airborne Direction Finding and Surveillance System (ADFSS)

RFI investigations

RFI investigations are initiated from three sources: The ESMC frequency management office, the ESMC frequency controller or the Kennedy Space Center (KSC) frequency management office.

Upon notification of an RFI problem, FCA personnel complete a RFI data form (figure 3) with the intent of compiling as much background information as possible about the problem.

All coordination of the RFI investigation is conducted by the FCA engineer from the FCA console. Radio link voice communications is maintained throughout the operation between all participants and the console.

If the RFI signal can be detected from the FCA console, the console DF equipment is used to determine an initial azimuth bearing of the RFI emitter.

One or both FCA vans, depending on the particular circumstances, are then dispatched to obtain additional azimuth bearings on the RFI.

All DF measurements are plotted on a large area map, located in the console area, to pinpoint the RFI source.

If necessary, measurement equipment can be easily removed from the vans and transported to the interior of buildings or launch structures to narrow down the RFI source even further.

Launch support

RF surveillance for ESMC launch support is divided into two categories: Launch vehicle and news media surveillance.

Twenty four hours prior to the scheduled support, the FCA engineering office prepares a complete listing of all applicable launch vehicle frequencies. In addition, a listing is prepared of all news media visitors and the frequencies on which they intend to operate any RF equipment.

Four hours prior to launch, one FCA van is dispatched to a predetermined RF surveillance monitoring site in the vicinity of the launch complex. A baseline spectrum signature plot is made of all applicable launch vehicle and flight termination frequencies. Van personnel then provide a continuous monitor, through vehicle liftoff, of the frequency spectrum. Any anomalies noted are reported to the ESMC frequency controller for appropriate action.

A second FCA van is dispatched to the applicable press site. A baseline spectrum signature plot is made of all news media RF emitters to determine if they are operating on their assigned frequencies. Van personnel then provide a continuous monitor, through vehicle liftoff, of the frequency spectrum. Any news media RF transmissions that infringe on the launch vehicle or flight termination frequencies are reported to the ESMC frequency controller and press site public affairs officer for immediate corrective action.

In addition to the FCA van coverage, the FCA console provides continuous frequency spectrum monitoring of the launch vehicle and flight termination frequencies throughout the mission support period. The FCA console also provides the capability of recording the flight termination system relative RF field strength and command functions along with IRIG H timing throughout the mission.

Radio Area Sensor System (RASS)

The RASS system consists of three solar powered remote monitoring stations and one central recording station that provide a twenty four hour, seven day per week monitor of the primary ESMC flight termination frequency. The three remote sites are located near the north boundry, south boundry and center of the ESMC launch facilitiy. The central recording station is located in the FCA console.

Any RF emitter, tuned to the flight termination frequency, within the range of the RASS is detected by one or more of the remote sites. Each remote site relays the presence of a RF emitter to the central recording station by way of an RF link. The central recording station event recorder automatically records which station or stations detected the emitter along with the time the RF emissions started and stopped.

In addition to providing a twenty four hour record of flight termination frequency events, the RASS is used to provide the FCA console operator with a "quick look" location for RFI emitters. This reduces the amount of time and travel required for the FCA vans to pinpoint the RFI source.

Figure 4 is a block diagram of the RASS.

Airborne Direction Finding and Surveillance System (ADFSS)

The ADFSS consists of one equipment pallet and one directional antenna tuned to the flight termination frequency. Figure 5 is a block diagram of the equipment pallet. Figure 6 shows the mounting arrangement of the ADFSS when mounted on board the aircraft.

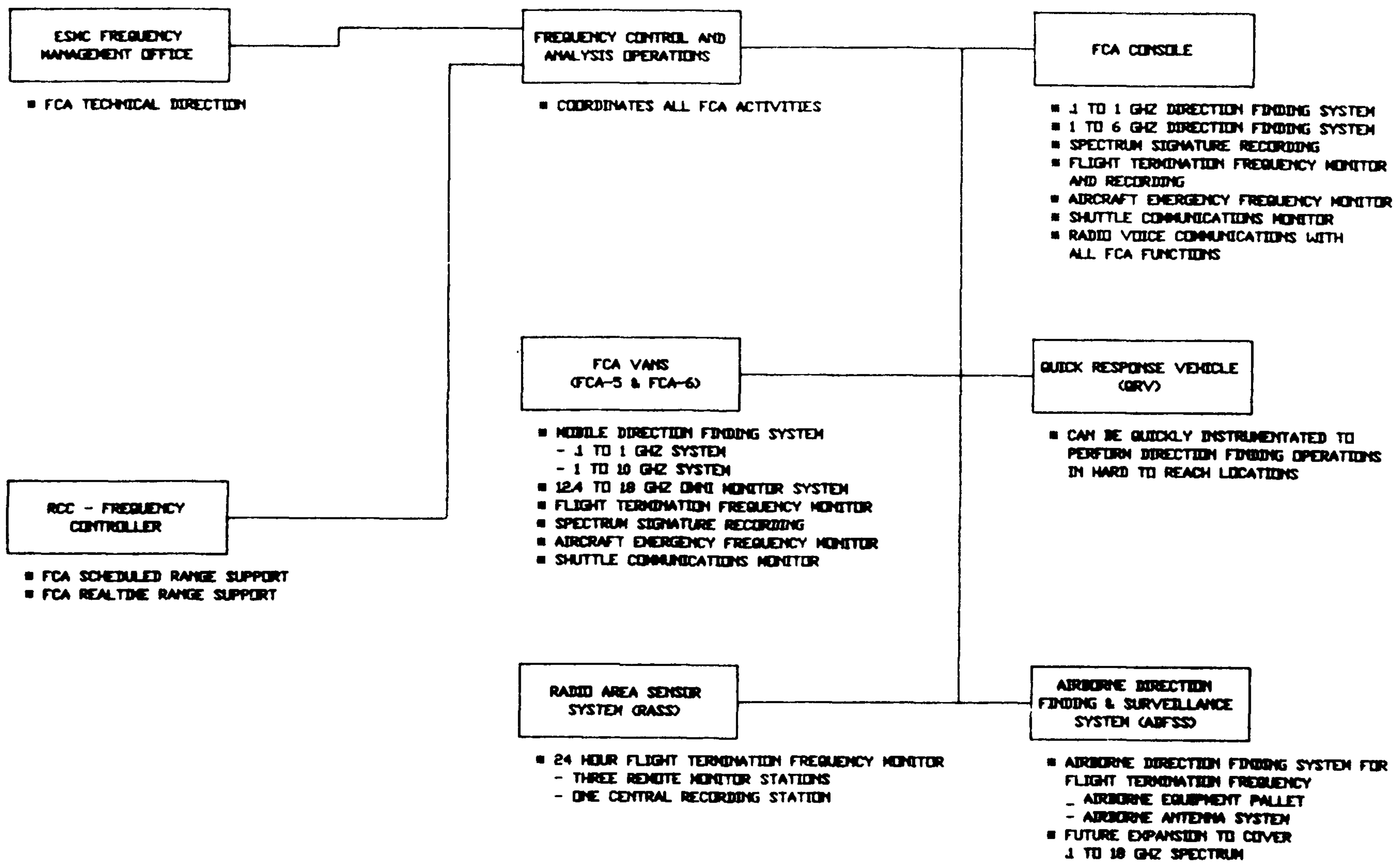
All DF operations using the ADFSS are coordinated at the FCA console by the FCA engineer who maintaines constant radio link voice communications with the aircraft and equipment operator throughout the operation.

Since the DF antenna on the aircraft is mounted at right angles to the direction of flight, all DF measurements are made by flying a racetrack pattern on a line perpindicular to the bearing of the RF source. When the aircraft reaches the point of maximum signal strength along this line, the equipment operator marks the aircraft heading along with the TACAN distance and bearing information for the aircraft position. This information is then relayed to the FCA console where it is loaded into the console computer. When two DF measurements are received, the console computer will output the range and bearing from the FCA console to the RF emitter.

Future plans for the ADFSS include relocation of the DF antenna to point in the direction of flight and to expand the frequency range of the system to cover from 100 MHz to 18 GHz.

RF Surveillance Equipment List

Table 1 through 3 are a tabulation of RF surveillance equipment used with the FCA console, FCA vans and auxiliary equipment.



ESMC FCA FUNCTIONAL BLOCK DIAGRAM

FIGURE 1A

EASTERN SPACE AND MISSILE CENTER

FREQUENCY CONTROL AND ANALYSIS SECTION

RF SURVEILLANCE SYSTEM SENSITIVITIES

416.5 MHZ REMOTE SITE MONITORS

-108 DBM

416.5 MHZ AIRBORNE DF SURVEILLANCE SYSTEM

-20 DB *

FCA CONSOLE

416.5 MHZ CR-104 RECEIVER SYSTEM

-110 DBM

416.5 MHZ DF SYSTEM

-9 DB *

VHF/UHF SCANNER MONITOR SYSTEM

FM/-117 DBM AM/-113 DBM

121.5 MHZ AIRCRAFT EMERGENCY RECEIVER SYSTEM

-110 DBM

243 MHZ AIRCRAFT EMERGENCY RECEIVER SYSTEM

-108 DBM

.1 - 1 GHZ DF SYSTEM

-25 DB *

1 - 6 GHZ DF SYSTEM

1 GHZ/-32 DB * 3 GHZ/-38 DB * 5 GHZ/-23 DB *

FCA INSTRUMENTATION VANS

416.5 MHZ CR-105 RECEIVER SYSTEM

-112 DBM

VHF/UHF SCANNER MONITOR SYSTEM

FM/-117 DBM   AM/-113 DBM

121.5 MHZ AIRCRAFT EMERGENCY RECEIVER SYSTEM

-110 DBM

243 MHZ AIRCRAFT EMERGENCY RECEIVER SYSTEM

-108 DBM

.1 - 1 GHZ DF SYSTEM

-30 DB *

1 - 10 GHZ DF SYSTEM

1 GHZ/-37 DB *   4 GHZ/-46 DB *   8 GHZ/-35 DB *

12 - 18 GHZ MONITOR SYSTEM

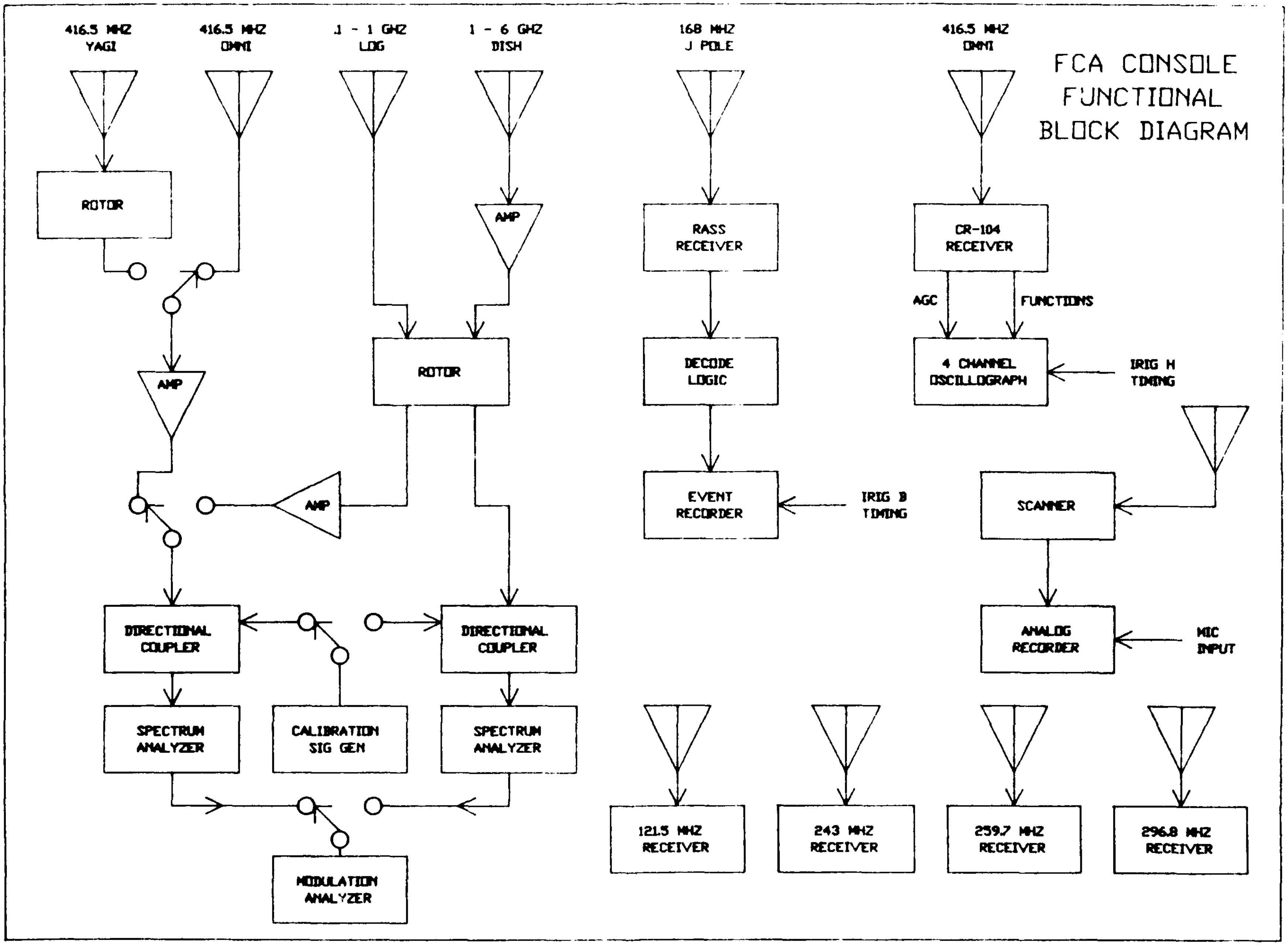
-24 DB *

* THESE VALUES WHEN ADDED TO THE SPECTRUM ANALYZER SENSITIVITY VALUE FOR THE PARTICULAR FREQUENCY AND RESOLUTION BANDWIDTH BEING USED WILL YIELD THE SYSTEM SENSITIVITY.

TYPICAL SPECTRUM ANALYZER SENSITIVITIES

RESOLUTION BANDWIDTH	CENTER FREQUENCY 10 MHZ	100 MHZ	1 GHZ	10 GHZ	20 GHZ
3 MHZ	-75 DBM	-75 DBM	-75 DBM	-68 DBM	-56 DBM
1 MHZ	-79 DBM	-79 DBM	-79 DBM	-72 DBM	-61 DBM
300 KHZ	-86 DBM	-86 DBM	-86 DBM	-78 DBM	-66 DBM
100 KHZ	-90 DBM	-90 DBM	-90 DBM	-82 DBM	-71 DBM
30 KHZ	-97 DBM	-97 DBM	-97 DBM	-89 DBM	-78 DBM
10 KHZ	-103 DBM	-103 DBM	-103 DBM	-94 DBM	-82 DBM
3 KHZ	-108 DBM	-108 DBM	-108 DBM	-100 DBM	-89 DBM
1 KHZ	-112 DBM	-112 DBM	-112 DBM	-105 DBM	-92 DBM
300 HZ	-118 DBM	-118 DBM	-118 DBM	-109 DBM	-99 DBM
100 HZ	-121 DBM	-122 DBM	-122 DBM	-110 DBM	-102 DBM
30 HZ	-127 DBM	-127 DBM	-127 DBM	-116 DBM	-108 DBM
10 HZ	-134 DBM	-134 DBM	-134 DBM	-124 DBM	-115 DBM

ALL MEASUREMENTS WERE TAKEN WITH THE SPECTRUM ANALYZER INPUT ATTENUATOR SET TO 0 DB, A REFERENCE LEVEL OF -40 DBM AND THE INPUT TERMINATED WITH A 50 OHM LOAD.


FCA CONSOLE
FUNCTIONAL
BLOCK DIAGRAM
416.5 MHZ YAGI
416.5 MHZ OMNI
.1 - 1 GHZ LOG
1 - 6 GHZ DISH
168 MHZ J POLE
416.5 MHZ OMNI
ROTOR
AMP
ROTOR
AMP
AMP
RASS RECEIVER
DECODE LOGIC
EVENT RECORDER
IRIG B TIMING
CR-104 RECEIVER
AGC
FUNCTIONS
4 CHANNEL OSCILLOGRAPH
IRIG H TIMING
SCANNER
ANALOG RECORDER
MIC INPUT
DIRECTIONAL COUPLER
DIRECTIONAL COUPLER
SPECTRUM ANALYZER
CALIBRATION SIG GEN
SPECTRUM ANALYZER
MODULATION ANALYZER
121.5 MHZ RECEIVER
243 MHZ RECEIVER
259.7 MHZ RECEIVER
296.8 MHZ RECEIVER

FIGUΓ .1

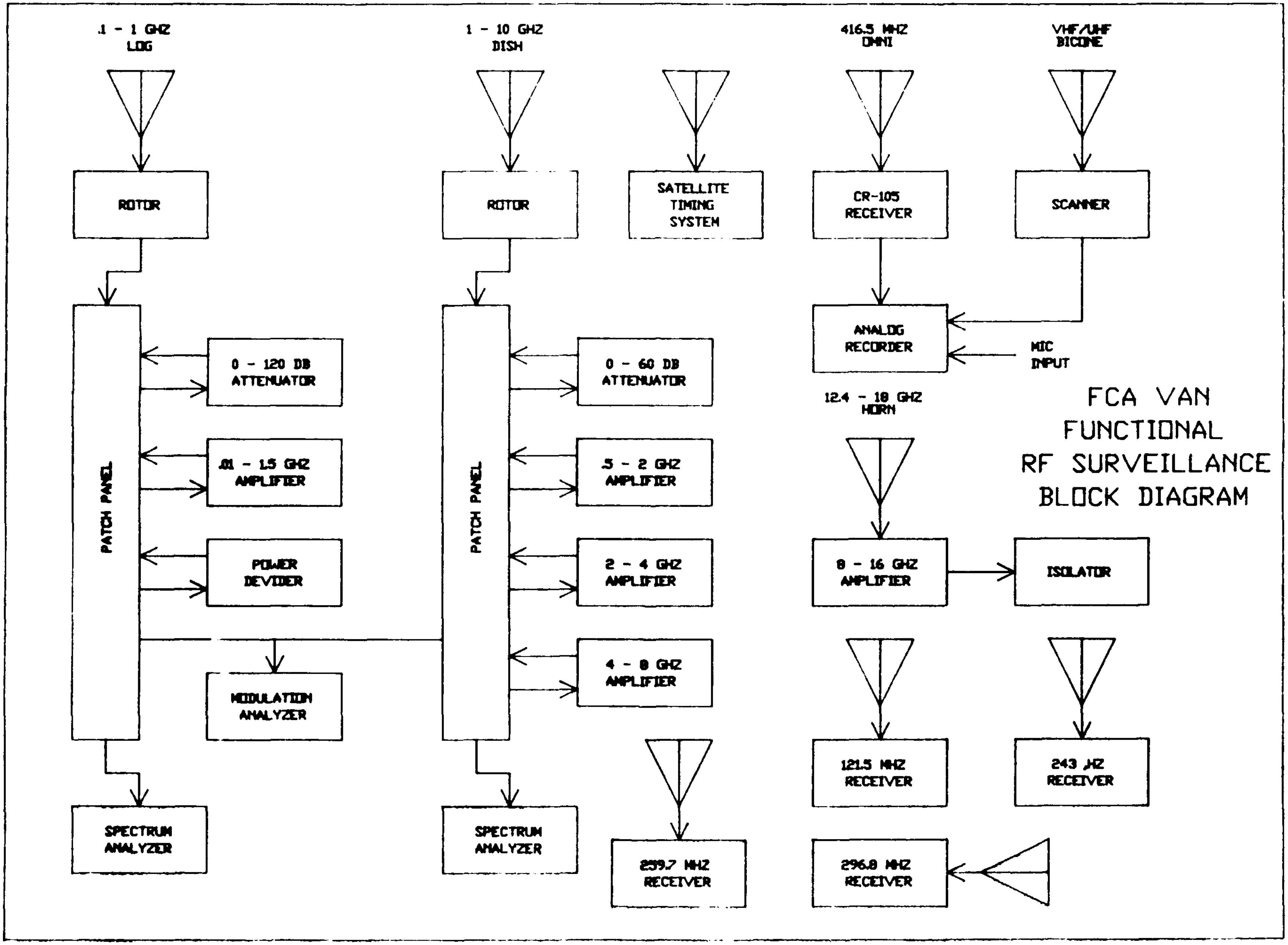

FCA VAN
FUNCTIONAL
RF SURVEILLANCE
BLOCK DIAGRAM
.1 - 1 GHZ
LOG
ROTOR
PATCH PANEL
0 - 120 DB
ATTENUATOR
.01 - 1.5 GHZ
AMPLIFIER
POWER
DEVIDER
MODULATION
ANALYZER
SPECTRUM
ANALYZER
1 - 10 GHZ
DISH
ROTOR
PATCH PANEL
0 - 60 DB
ATTENUATOR
.5 - 2 GHZ
AMPLIFIER
2 - 4 GHZ
AMPLIFIER
4 - 8 GHZ
AMPLIFIER
SPECTRUM
ANALYZER
SATELLITE
TIMING
SYSTEM
259.7 MHZ
RECEIVER
416.5 MHZ
OMNI
CR-105
RECEIVER
ANALOG
RECORDER
VHF/UHF
BICONE
SCANNER
MIC
INPUT
12.4 - 18 GHZ
HORN
8 - 16 GHZ
AMPLIFIER
ISOLATOR
121.5 MHZ
RECEIVER
243 MHZ
RECEIVER
296.8 MHZ
RECEIVER

FIGURE 2

FCA

RADIO FREQUENCY INTERFERENCE

DATA FORM

PREPARED BY ______________________

DATE ________________ TIME ______________ TEST# _________________

NOTIFIED BY __________ __________ __________ ____________________

NAME ORG. TELEPHONE LOCATION

AFFECTED PARTY __________ __________ __________ ____________________

NAME ORG. TELEPHONE LOCATION

AFFECTED SYSTEM ____

FREQ. OF CONCERN ______________________ AFFECTED SYSTEM BW _____________________

KHZ, MHZ, GHZ

SYSTEM ANTENNA TYPE ____

OMNI, DISH, HORN, LOG, WHIP, OTHER

ANTENNA LOCATION _____________________ ANTENNA HEIGHT ______________________

TYPE OF INTERFERENCE ____

PWR LEVEL (STRONG-WEAK), CW, SWEPT, PULSED

ADDITIONAL REMARKS ____

____

____

____

____

FIGURE 3

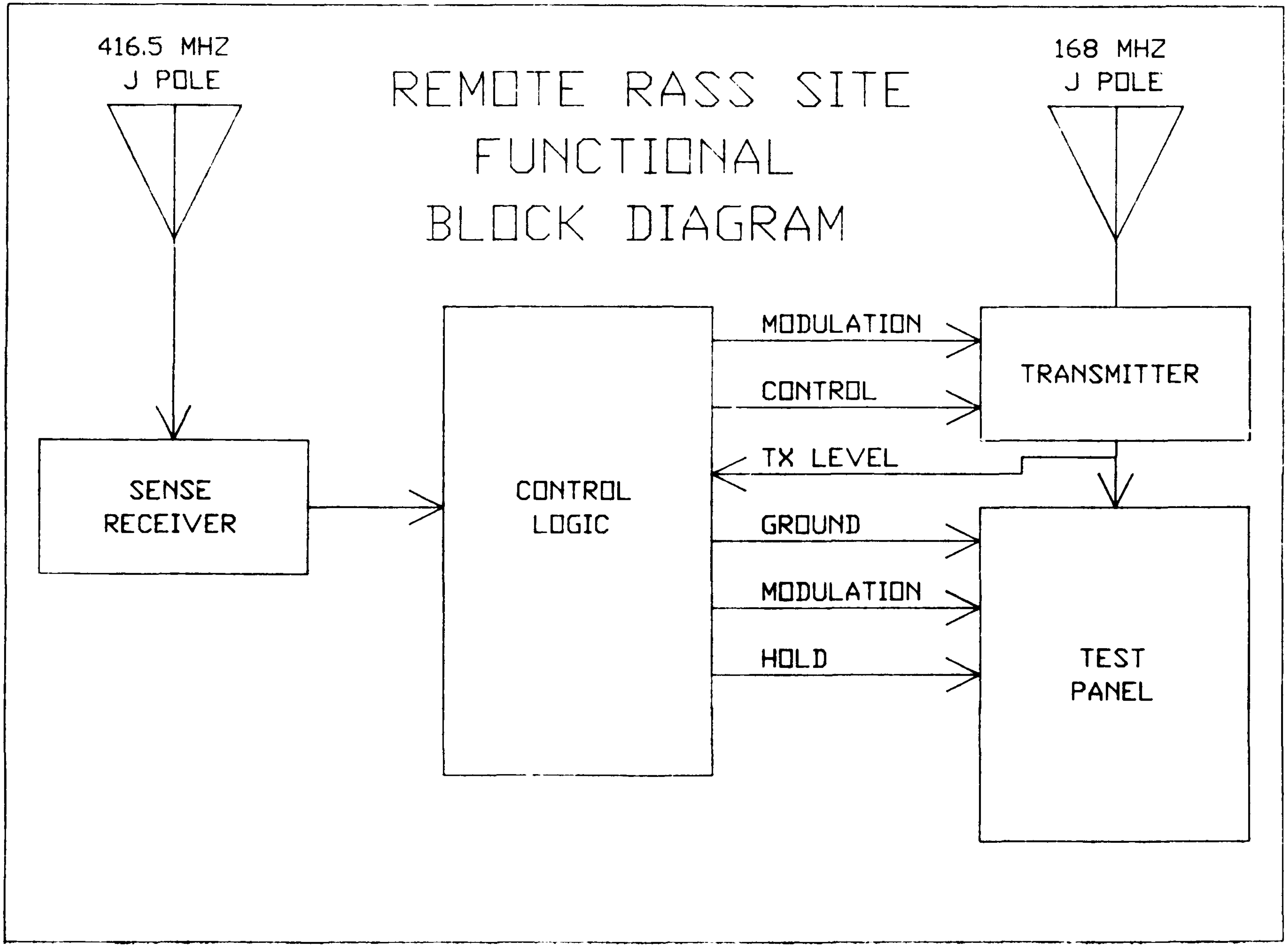
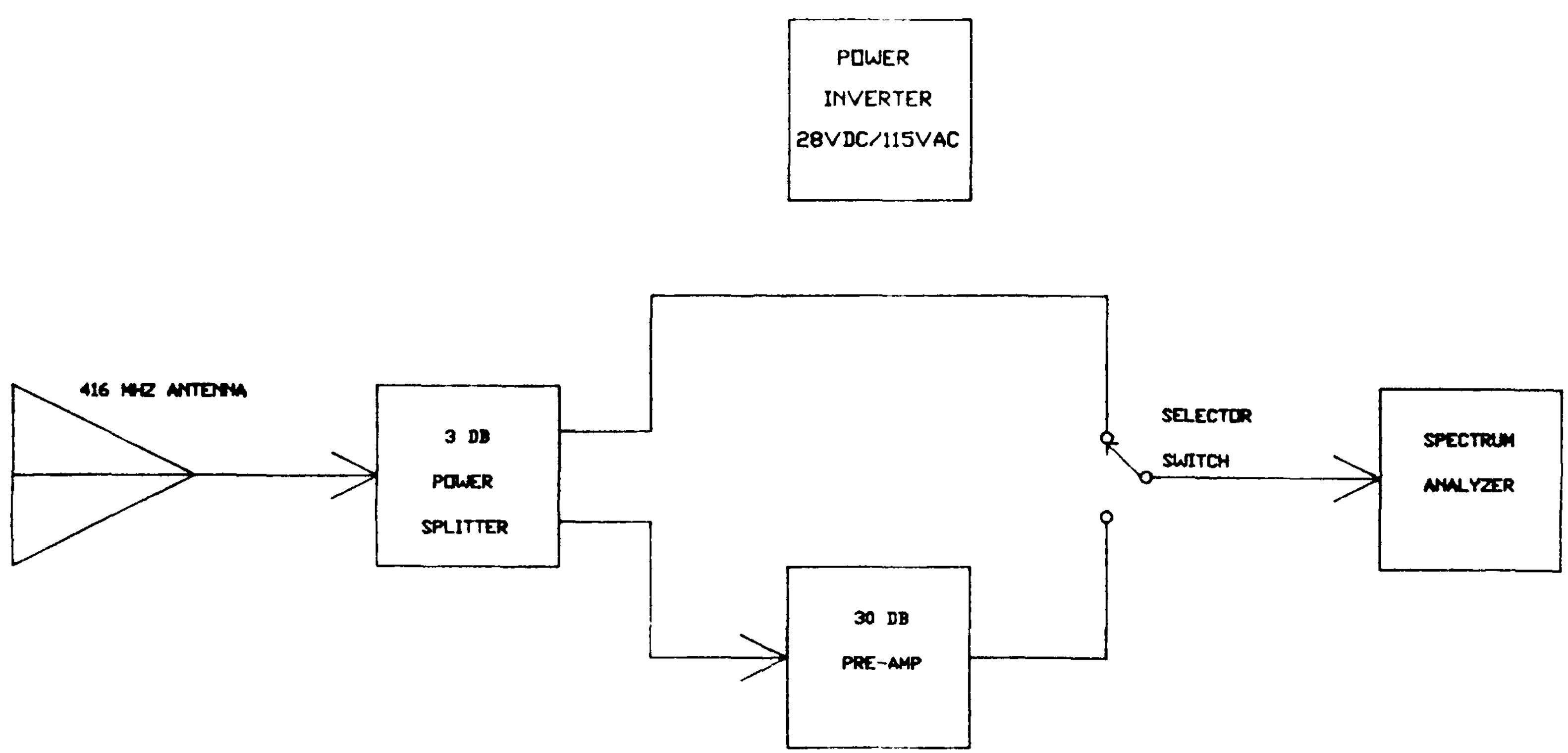

416.5 MHZ
J POLE
REMOTE RASS SITE
FUNCTIONAL
BLOCK DIAGRAM
168 MHZ
J POLE
SENSE
RECEIVER
CONTROL
LOGIC
MODULATION
CONTROL
TX LEVEL
GROUND
MODULATION
HOLD
TRANSMITTER
TEST
PANEL

FIGURE 4

ADFSS FLIGHT TEST EQUIPMENT BLOCK DIAGRAM



FIG' ˙ 5

ADFSS EQUIPMENT LAYOUT IN HELICOPTER

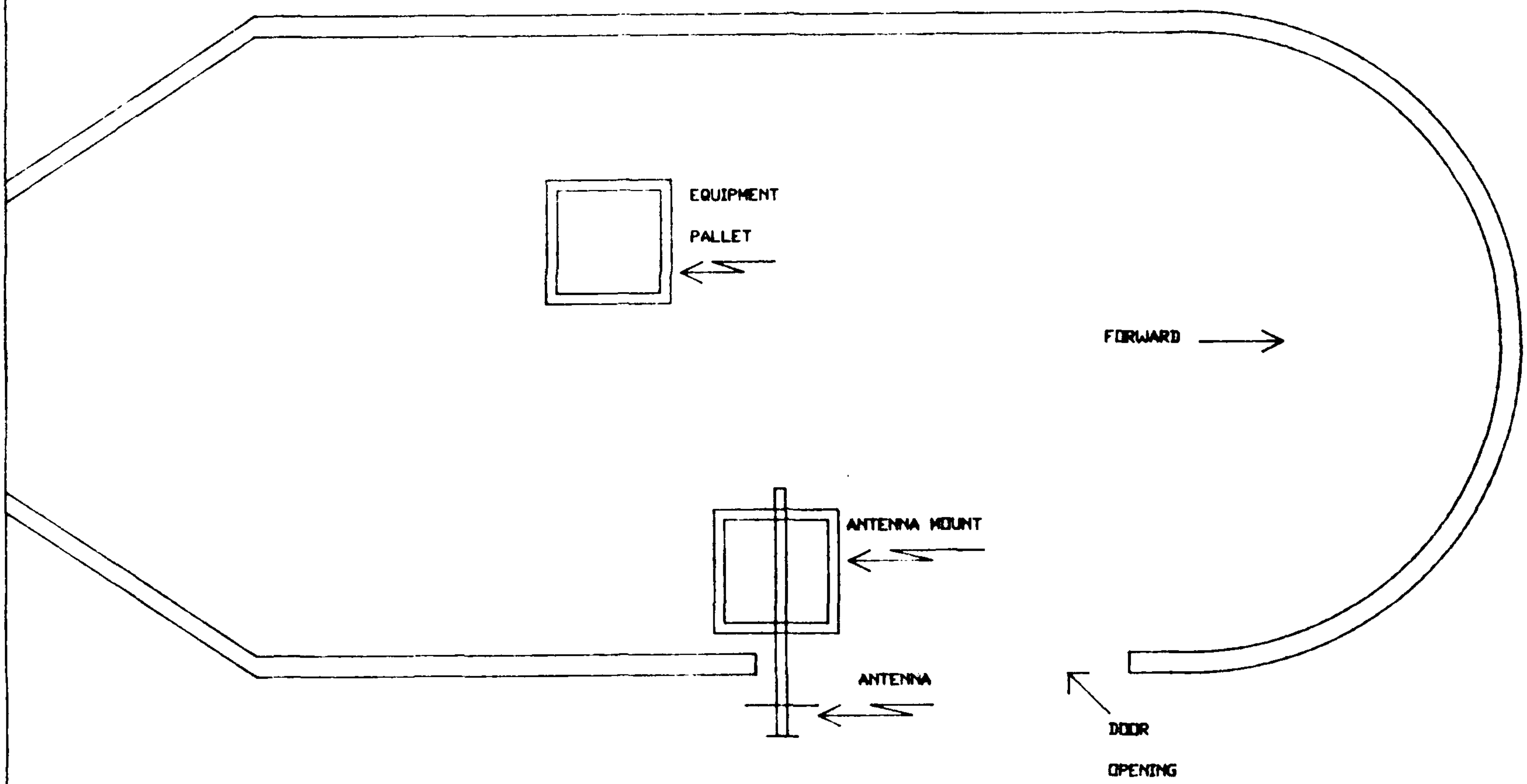


FIGURE 6

FCA CONSOLE

RF SURVEILLANCE

EQUIPMENT LIST

NOMENCLATURE	MODEL NO.	MANUFACTURER
DF Antenna 416.5 MHz Yagi	-	Local Fabrication
Antenna 416.5 MHz Omni	-	Local Fabrication
DF Antenna .1 - 1 GHz Log	201010A	TECOM Inc.
DF Antenna 1 - 6 GHz Dish	4 Foot	Andrews
Antenna 168 MHz "J" Pole	-	Local Fabrication
Antenna 416.5 MHz Omni	-	Local Fabrication
DF Antenna Rotor System (2ea)	PSE Series	Pro-Search Inc.
Amplifier 1 - 6 GHz	ACM633404	Amplica Inc.
Amplifier .1 - 1 GHz (2ea)	AF2033	Avantek Inc.
RASS Receiver/ Decoder System	-	Local Fabrication
RASS Event Recorder	HP-5150	Hewlett-Packard
Command Destruct Receiver	CR-104	Cincinnati Electronics
Oscillograph 4 Channel	ST-200RP	Gulton Inst.
Antenna VHF/UHF Biconical	94455-1	Stoddard

TABLE 1A

FCA CONSOLE

RF SURVEILLANCE

EQUIPMENT LIST

NOMENCLATURE	MODEL NO.	MANUFACTURER
VHF/UHF Scanner Receiver	AR-2002	AOR Ltd.
Analog Tape Recorder 4 Channel	HP-3964A	Hewlett-Packard
Directional Coupler (2ea)	HP-796D	Hewlett-Packard
Spectrum Analyzer (2ea)	HP-8559A	Hewlett-Packard
Modulation Analyzer	HP-8901A	Hewlett-Packard
Calibration Signal Generator .05 - 12 GHz	900	Giga-Tronics Inc.
121.5 MHz Receiver	-	Local Fabrication
243 MHz Receiver	-	Local Fabrication
259.7 MHz Receiver	-	Local Fabrication
296.8 MHz Receiver	-	Local Fabrication

TABLE 1B

FCA VAN

RF SURVEILLANCE

EQUIPMENT LIST

NOMENCLATURE	MODEL NO.	MANUFACTURER
DF Antenna System .1 - 1 GHz Log	DF-1	Scientific-Atlanta
DF Antenna System 1 - 10 GHz Dish	DF-2	Scientific-Atlanta
Antenna 416.5 MHz Omni	-	Local Fabrication
Command Destruct Receiver	CR-105	Cincinnati Electronics
Antenna VHF/UHF Biconical	94455-1	Stoddard
Satellite Timing Receiver System	468-DC	True Time Instruments Inc.
VHF/UHF Scanner Receiver	AR-2002	AOR Ltd.
Analog Tape Recorder 4 Channel	HP-3964A	Hewlett-Packard
Attenuator 0 - 120 dB (2ea)	HP-219-12612	Hewlett-Packard
Amplifier .01 - 1.5 GHz	AMG-1020M	Avantek
Power Divider	HP-11636A	Hewlett-Packard
Modulation Analyzer	HP-8901A	Hewlett-Packard
Spectrum Analyzer	HP-8559A	Hewlett-Packard
Amplifier .5 - 2 GHz	AFT-2033	Avantek
Amplifier 2 - 4 GHz	AFT-4233	Avantek

TABLE 2A

FCA VAN

RF SURVEILLANCE

EQUIPMENT LIST

NOMENCLATURE	MODEL NO.	MANUFACTURER
Amplifier 4 - 8 GHz	AFT-8464	Avantek
Spectrum Analyzer	HP-8566B	Hewlett-Packard
Antenna 12.4 - 18 GHz	639	Narda
Amplifier 8 - 18 GHz	09002	Narda
121.5 MHz Receiver	-	Local Fabrication
243 MHz Receiver	-	Local Fabrication
259.7 MHz Receiver	-	Local Fabrication
296.8 MHz Receiver	-	Local Fabrication

TABLE 2B

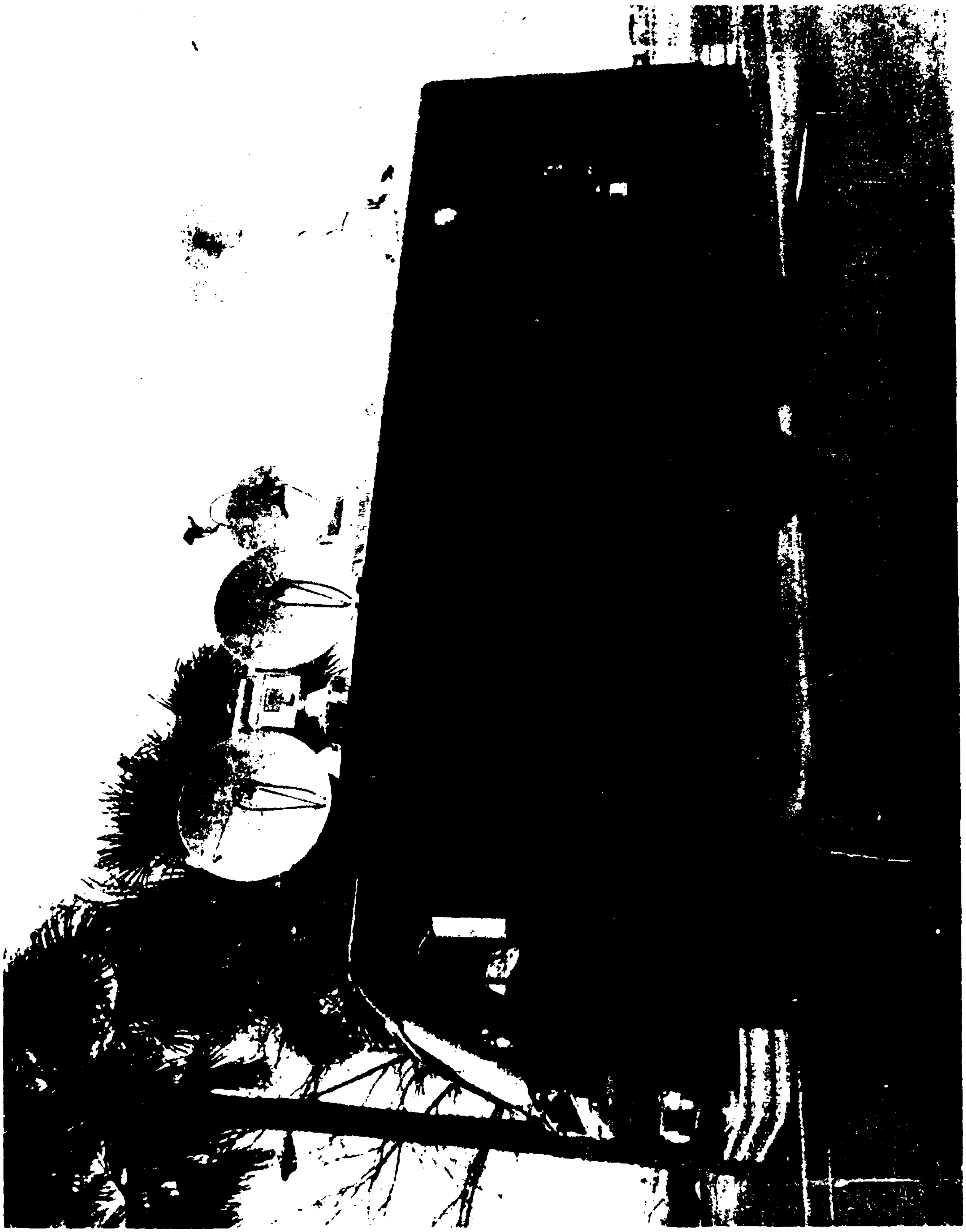
FCA AUXILIARY

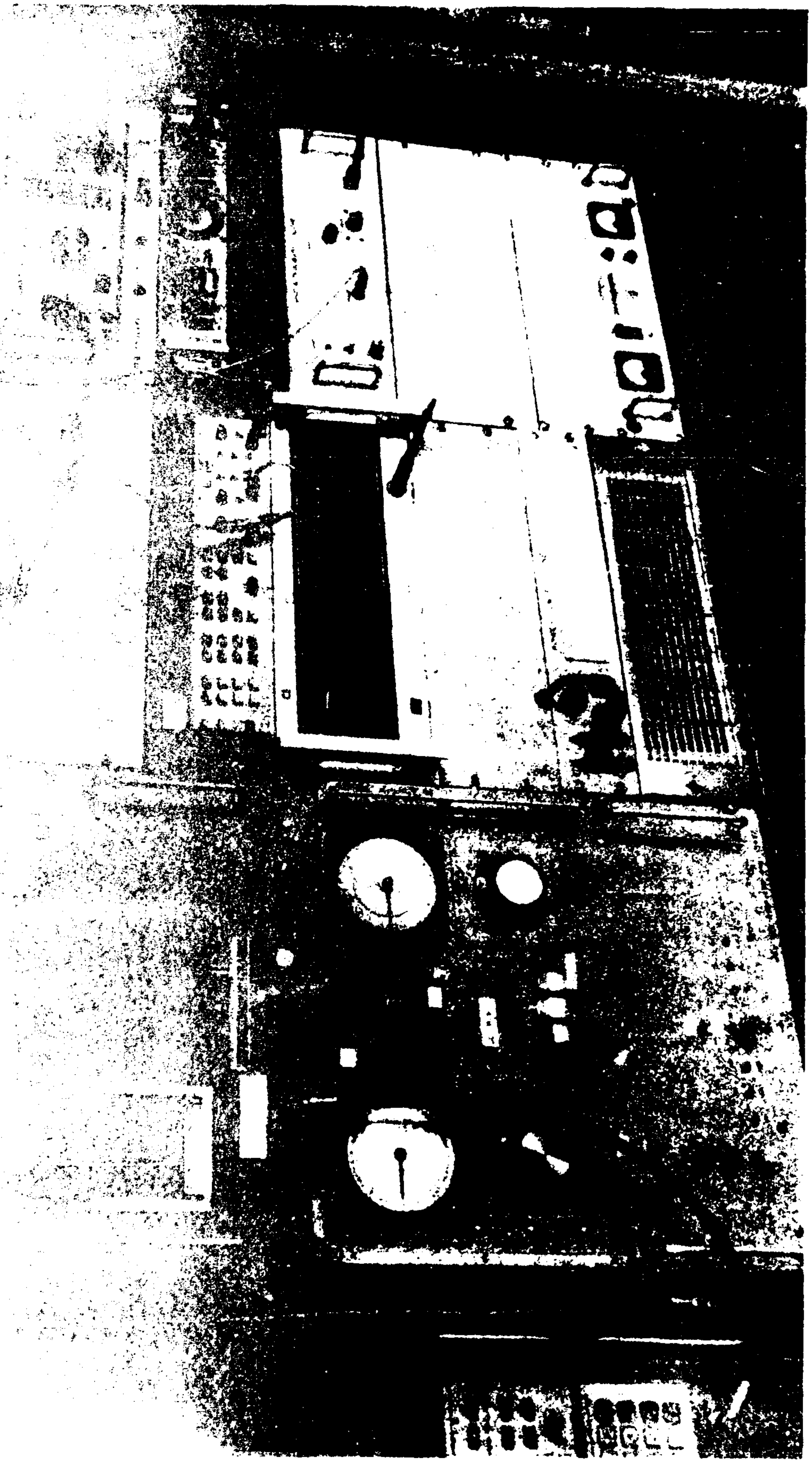
RF SURVEILLANCE

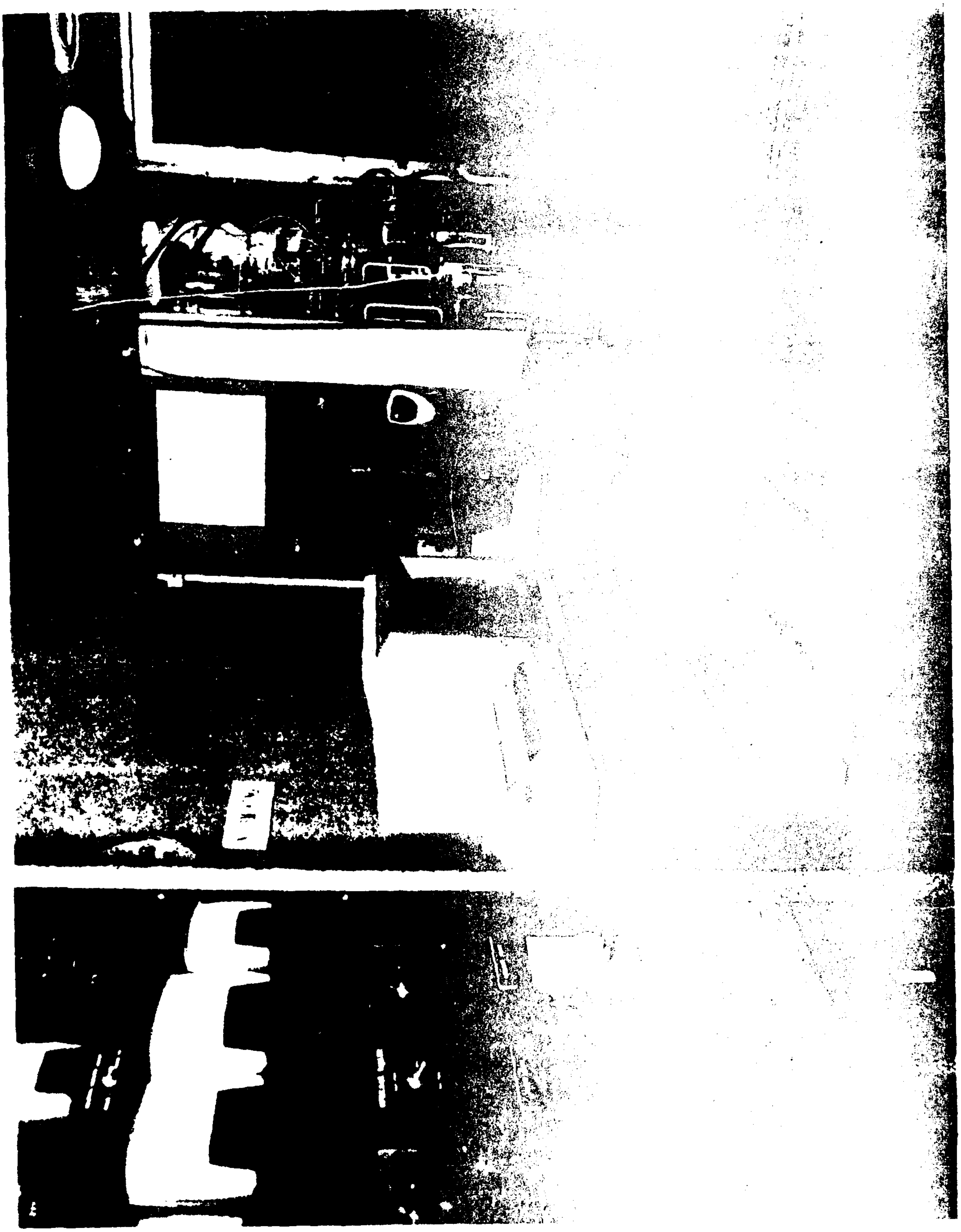
EQUIPMENT LIST

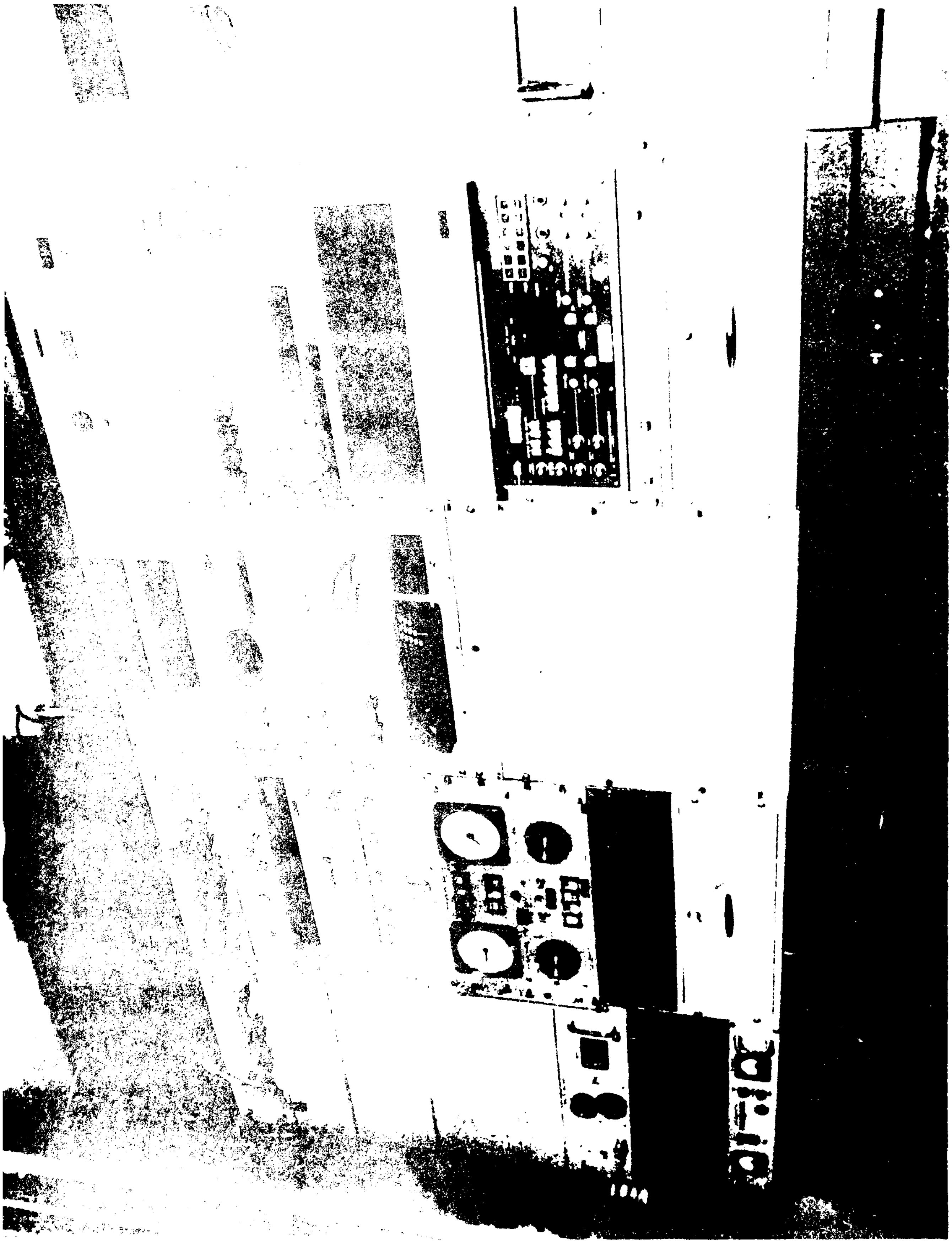
NOMENCLATURE	MODEL NO.	MANUFACTURER
	ADFSS SYSTEM	
Antenna 416.5 MHz	-	Local Fabrication
Amplifier .1 - 1 GHz	AF2033	Avantek
Spectrum Analyzer	HP-8559A	Hewlett-Packard
Power Divider	HP-11636A	Hewlett-Packard
RF Selector Switch	STN2180A	Sage Labs
Static Power Inverter	2A1000-1G	Avionic Inc.
	RASS REMOTE SITES	
RASS Remote Monitoring Site (3ea)	-	Local Fabrication

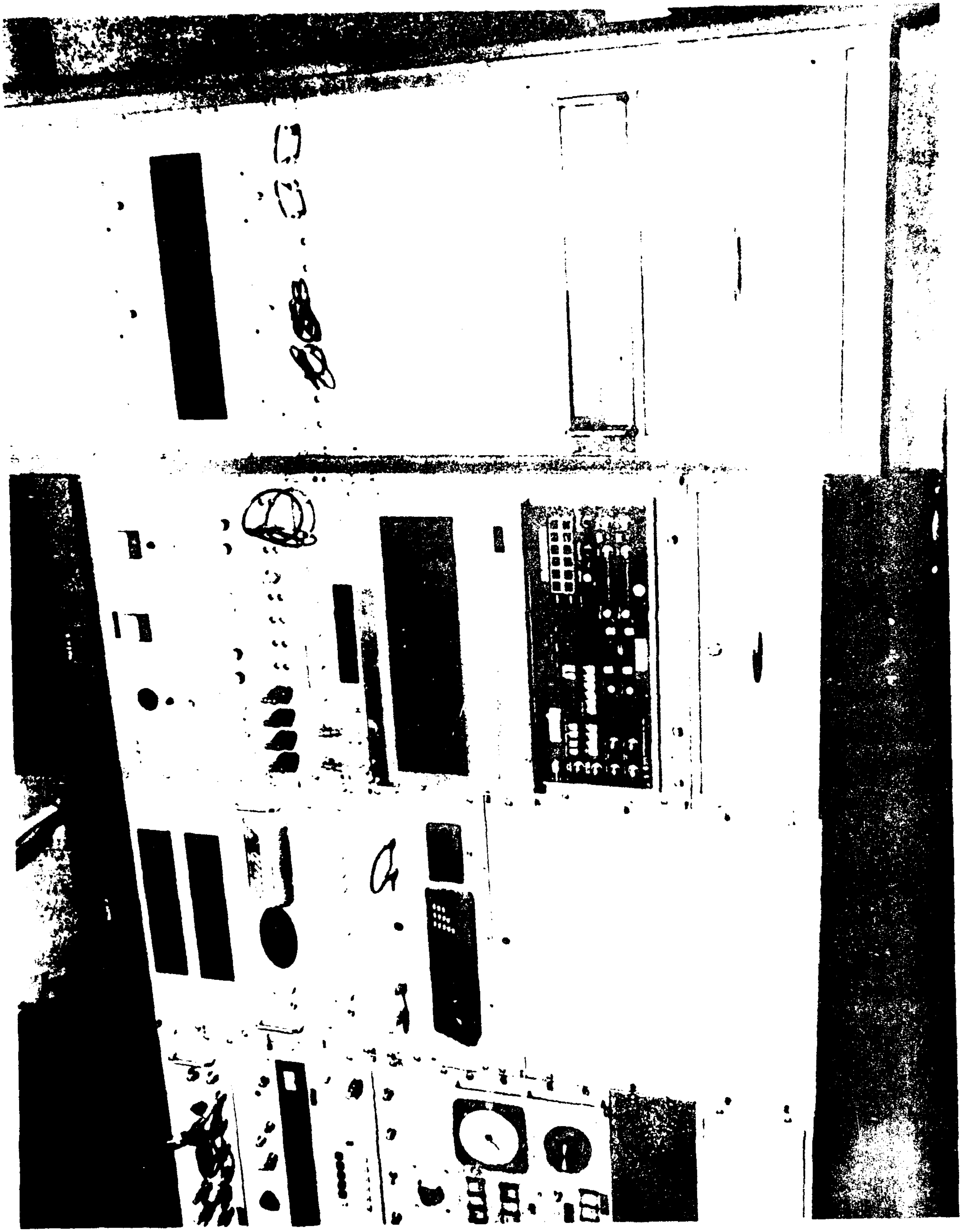
TABLE 3

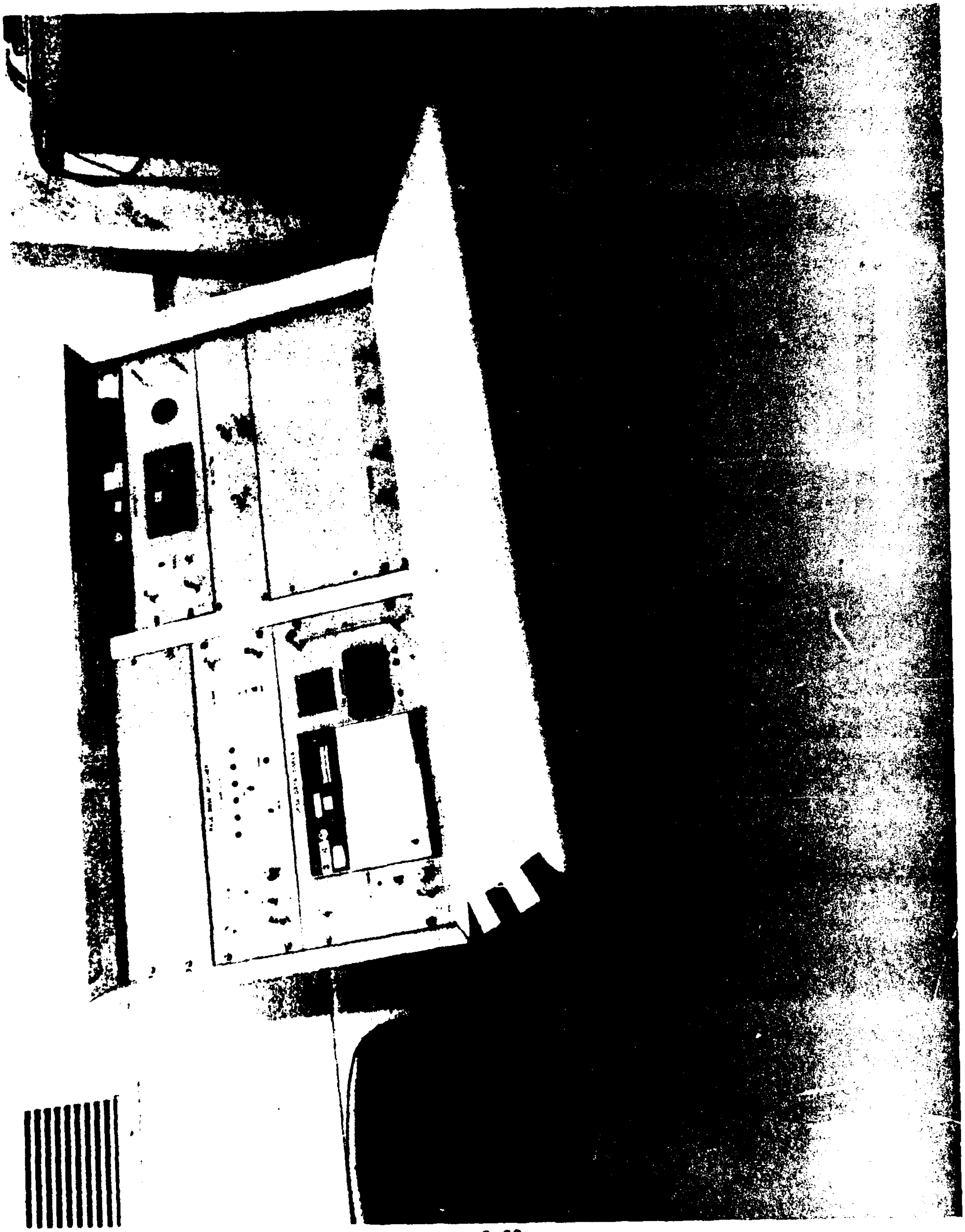


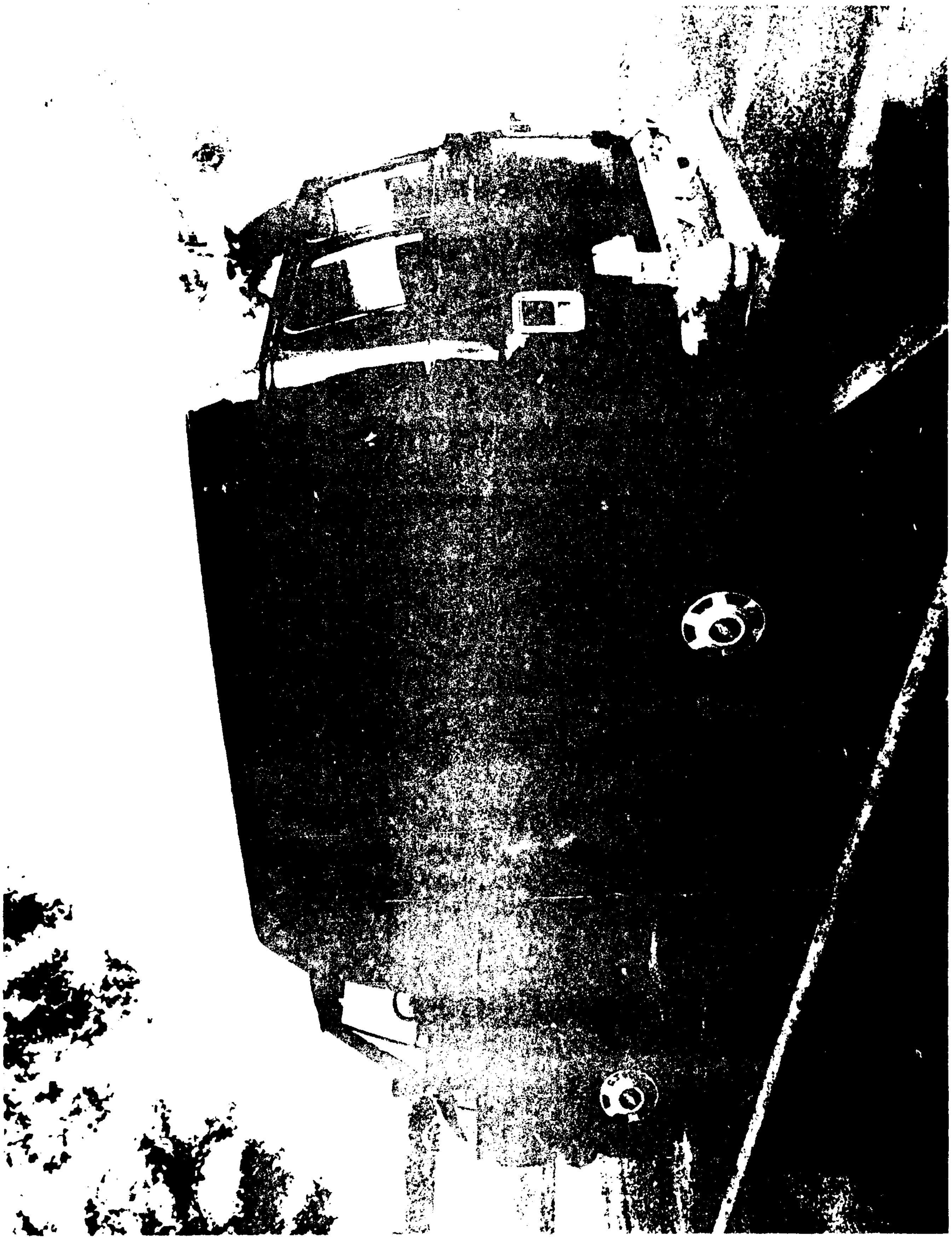


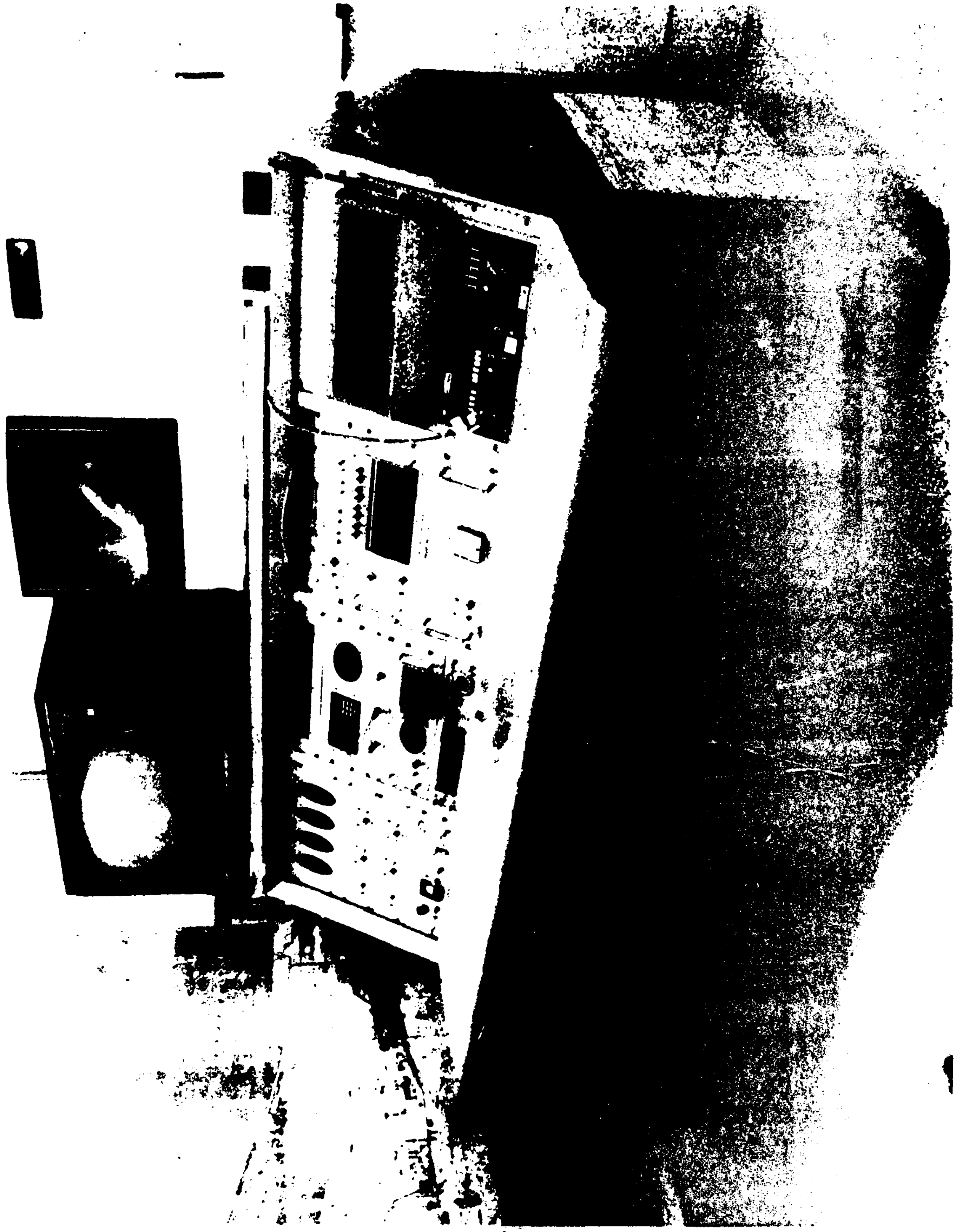












APPENDIX D

U.S. ARMY KWAJALEIN ATOLL

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

PRC Kentron	U.S. ARMY KWAJALEIN ATOLL (USAKA)		
PROCEDURE NO. SOP 213.001	DATE 15 Mar 87	TITLE FREQUENCY CONTROL AND ANALYSIS OPERATION AND MAINTENANCE	PAGE 1 OF 24
APPROVED MANAGER, ENGINEERING GROUP		PREPARED BY PRINCIPAL FCA TECHNICIAN	
REVIEWED PERFORMANCE ASSURANCE SUPERVISOR		REVIEWED UNIT LEADER, ELECTRONICS LABORATORY	

1.0 INTRODUCTION

1.1 General

1.1.1 The U. S. Army Kwajalein Atoll (USAKA) Frequency Control and Analysis (FCA) facility consists of a mobile Radio Frequency (RF) surveillance system, which performs the functions necessary to monitor and control the electromagnetic environment. Control of the electromagnetic environment is accomplished by Electromagnetic Compatibility (EMC) measurements for personnel and ordnance safety.

1.1.2 The RF Measurements Van is used to perform field intensity and power density measurements on specific transmitting equipment for determination of RF hazards to personnel and ordnance. The mobile van is also utilized to locate Electromagnetic Interference (EMI) on a case-by-case basis, and performs limited frequency spectrum surveillance and direction-finding, frequency measurements, and data recording and analysis.

1.1.3 A representative of the FCA Section will serve as a point-of contact to the USAKA Area Frequency Coordinator (AFC) and will fulfill the requirements outlined in USAKA Regulation 105-2, Section 5b.

1.2 Purpose

This document provides the necessary procedures and information for operation and maintenance of the Frequency Control and Analysis Equipment at USAKA by the Range Engineering, Data Acquisition and Reduction Contractor (REDARC).

1.3 Scope

1.3.1 Procedures

Included in this SOP are the procedures for mission activities and FCA Data Base collection and reporting.

1.3.2 Applicability

This procedure applies to the Range Electronics Laboratory Unit Leader, the personnel assigned to the Operations and Maintenance (O&M) of the FCA Equipment, and to designated personnel at the various USAKA land-based and mobile systems locations.

1.3.3 Compliance

This procedure complies with the REDAR Contract Scope of Work (SOW), dated 13 October 1983, Paragraph 3.8.

1.3.4 Associated REDARC Procedures

SOP 003.005, Maintenance Management Program (MMP).

1.3.5 References

Where appropriate, references are made to manufacturer's or vendor specifications, procedures, technical documents, and maintenance recommendations.

1.4 Responsibilities

1.4.1 The Range Electronics Laboratory (E-Lab) Unit Leader has overall responsibility to ensure that these procedures are implemented, results evaluated, and revisions made, in a timely manner.

1.4.2 The E-Lab Unit Leader delegates authority to the FCA Principle Technician who assigns technicians to the FCA Unit with appropriate training and skill to operate and maintain FCA equipment per these established procedures. The FCA Principle Technician submits appropriate reports and records to the E-Lab Unit Leader, along with other data, records, and reports, as required.

1.4.3 The FCA technicians will perform the assigned FCA O&M tasks. They will maintain the Preventive Maintenance (PM) documentation and a history of Corrective Maintenance (CM) activity, and provide data and records as required.

2.0 SYSTEM OPERATION AND DESCRIPTION

2.1 System Operation

2.1.1 The FCA Equipment is set up, checked out, and operated by FCA personnel per this procedure. Functional operations include the Kwajalein RF Measurements Van, along with various other FCA equipment required at Kwajalein and the outer island sites. The following functions are performed by the FCA Unit.

2.1.1.1 Performs measurements and provides data to determine the electromagnetic compatibility of existing instrumentation systems or sensors with new instrumentation or sensors.

2.1.1.2 Conducts RF surveys in accordance with USAKA approved test plans and reduces the survey data into useable engineering units.

2.1.1.3 Provides RF survey data for evaluation of potential RF radiation hazards to personnel and electro-explosive devices, in support of range safety and range user requirements.

2.1.1.4 **Participates in pre-mission planning meetings, conducts** pre-mission checks and calibrations to assure adequate system performance, and during missions, conducts surveillance of the frequency spectrum to detect, locate, analyze, and identify any source of Electromagnetic Interference (EMI) that may affect data gathering

2.1.1.5 Maintains on file a list of all frequencies authorized for use at USAKA.

2.1.1.6 Provides input data to the Area Frequency Coordinator in accordance with USAKA Regulation 105-2, Section 5b.

2.1.1.7 Inspects microwave cooking ovens on a non-interference to mission basis.

2.2 System Description

2.2.1 RF Measurements Van (RF Van)

The RF Van consists of an International Harvester truck with a Craig Systems Corporation EMI shielded, environmentally controlled work area.

The RF Van has the major capability of measuring radiated field intensity within a frequency range of 10 KHz to 18 GHz. Limited EM measurements from 26.5 GHz to 40 GHz and 93.5 GHz to 97.5 GHz can also be made. Figure 1 presents a block diagram of the RF van.

2.2.1.1 The RF receiver system consists of the following Electromagnetic Interference (EMI)/field intensity meters and Millimeter Wave (MMW) receiver/downconverters:

MODEL	FREQUENCY RANGE
Ailtech NM-17/27	10 MHz - 32 MHz
Ailtech NM-37/57	30 MHz - 1 GHz
Ailtech NM-67	1 GHz - 18 GHz
Alpha 70078200	26.5 GHz - 40 GHz
Alpha 70088600	93.5 GHz - 97.5 GHz

The Ailtech EMI/field intensity meters are solid-state in design, make use of electronic sweeping and band switching techniques, and are used in conjunction with a variety of calibrated antennas. The Ailtech meters can also be used in a portable mode to facilitate measurements in remote areas, such as antenna domes, buildings, and aircraft.

The Alpha MMW receivers downconvert the K_a and W band signals to intermediate frequencies that can be processed in the RF Van.

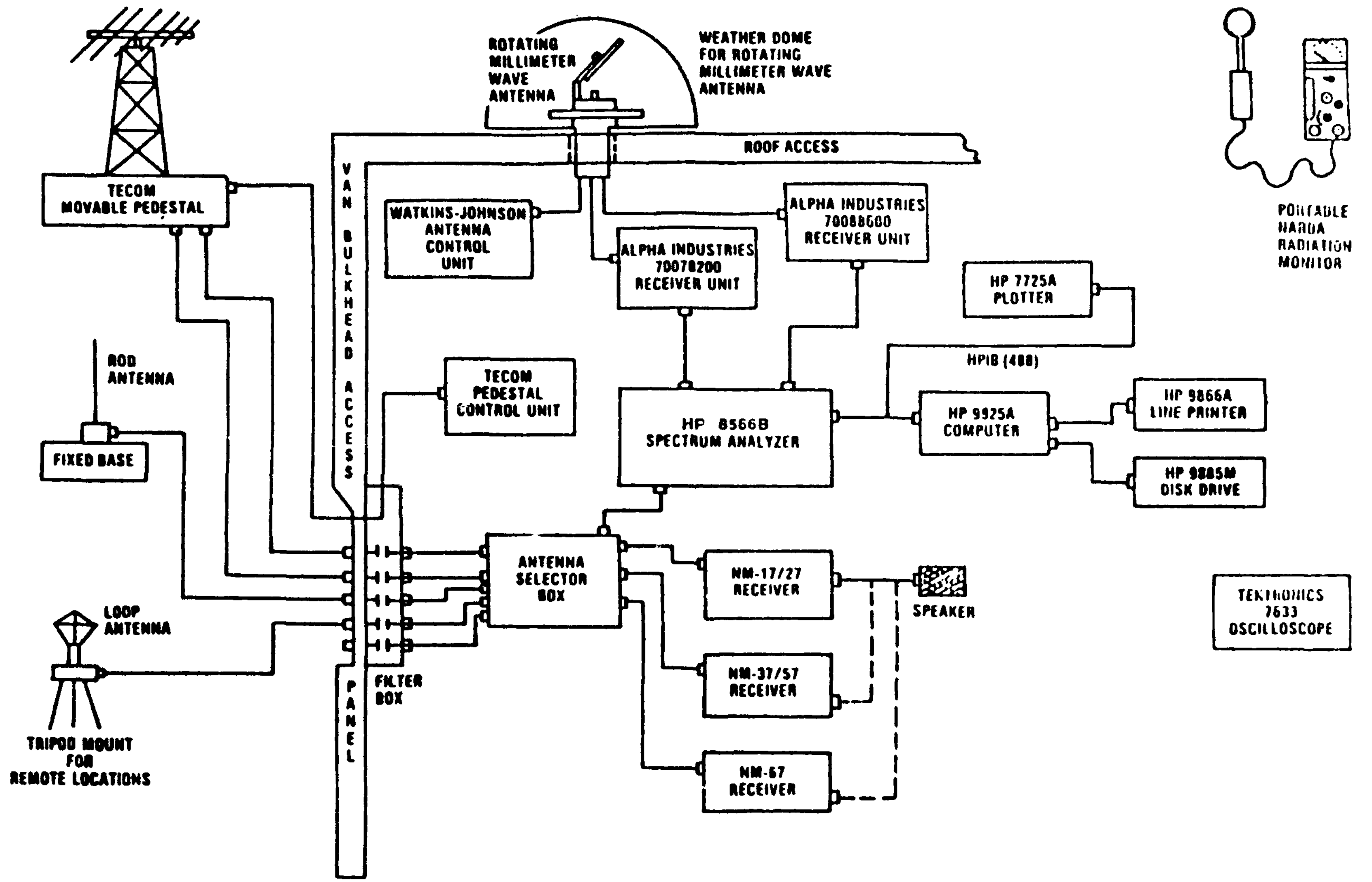


FIGURE 1. FCA VAN BLOCK DIAGRAM

2.2.1.2 Antennas used with the RF receivers are listed below:

	MODEL	TYPE	MFG	S/N	FREQ RANGE
1.	640	Horn	Narda	7083	8.2 - 12.4 GHz
2.	642	Horn	Narda	7703	5.3 - 8.2 GHz
3.	643	Horn	Narda	7703	3.95 - 5.85 GHz
4.	644	Horn	Narda	10089	2.6 - 3.95 GHz
5.	644	Horn	Narda	5030	2.6 - 3.95 GHz
6.	645	Horn	Narda	9015	1.7 - 2.6 GHz
7.	93491-2	Cone	Ailtech	159	1.0 - 10.0 GHz
8.	93491-2	Cone	Ailtech	258	1.0 - 10.0 GHz
9.	94455-1	Biconical	Ailtech	524	.02 - .2 GHz
10.	DM-105A-T2	Dipole	Ailtech	116	.14 - .4 GHz
11.	DM-105A-T3	Dipole	Ailtech	120	.4 - 1.0 GHz
12.	92197-3 92198-3	Rod and Coupler	Stoddart	531	.15 - 32.0 MHz
13.	92197-3 92198-3	Rod and Coupler	Stoddart	DC120	.15 - 32.0 MHz
14.	92200-3	Loop	Stoddart	DD56	.15 - 32.0 MHz
15.	94593-1	Loop and Coupler	Singer	194	.01 - 32.0 MHz
16.	201009A	Log Per.	Tecom	40	.09 - 1.0 GHz
17.	201191A	Omnidir.	Tecom	52	20 Hz - 1.0 GHz

Calibration charts for the antennas are located in the FCA office and the file cabinet of the RF Van.

A rotating antenna mast is used to point the directional antennas; the bearing is selected from within the RF Van using the Positioner Control Unit (PCU) and includes an indicator that displays antenna direction.

2.2.1.3 The Computerized Spectrum Search Program for the Hewlett-Packard (HP) 9825A Calculator/Computer allows the operator to scan a user-defined range of frequencies automatically. The operator can also chart the HP-8566B Spectrum Analyzer display onto an HP-[illegible] Graphics Plotter.

2.2.1.4 Ancillary equipment used in the RF Van consists of an oscilloscope, multimeter, FM wireless headsets, and Portamobile radios. A towed, trailer-mounted, diesel electrical generator supplies 60-cycle, 230 VAC power to the RF Van. Connectors located next to the van door permit external power drops and communications networks to be utilized.

Figure 2 presents an Equipment Rack Layout of the FCA RF Van.

2.2.2 Narda Radiation Monitors

Two different types of Narda Radiation Monitors are used for monitoring work. Specific uses and frequency ranges that pertain to each monitor are described here. Both measure power density.

2.2.2.1 Model 8616 is a Broadband Isotropic Radiation Monitoring System which covers the frequency range of 10 MHz to 40 GHz, and 95.5 GHz and measures. This monitor provides total integration of radiated power over the entire stated frequency spectrum and is used for most RF hazard survey work.

Refer to Section II of the 8616 O&M Manual for operating instructions.

2.2.2.2 Model 8201 Electromagnetic Leakage Monitor is used for determining the amount of microwave energy radiated by industrial and domestic ovens, heaters and dryers, using microwave power at 2450 MHz.

Refer to Section II of the 8201 O&M Manual for operating instructions.

2.2.3 Database of USAKA Frequency Assignments

A complete listing of frequency assignments is stored in the ICC 6400 Computer and can be accessed via the MTC ASR-33 Teletype data entry terminal. Hardcopies of the listing are located in the FCA office and RF Van. See Annex I for database procedures.

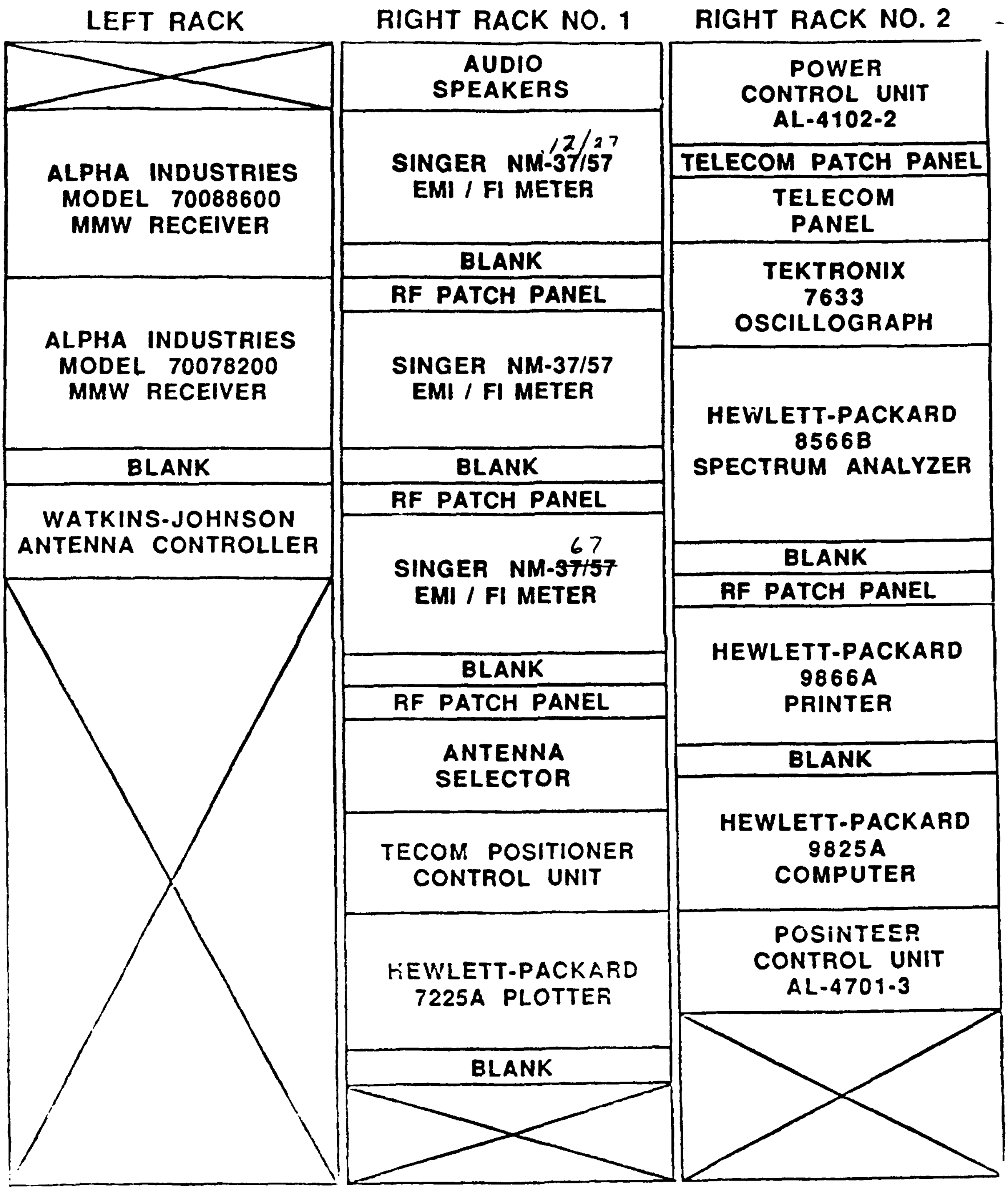


FIGURE 2
RF VAN EQUIPMENT RACK LAYOUT

2.3 Equipment Technical Characteristics

2.3.1 Receiver, NM-17/27 EMI, Ailtech

Frequency

Range: 0.01 MHz to 32 MHz in 8 bands.

Band 1 -	0.01	to	0.25	MHz
Band 2 -	0.25	to	0.5	MHz
Band 3 -	1.0	to	1.0	MHz
Band 4 -	1.0	to	2.0	MHz
Band 5 -	2.0	to	4.0	MHz
Band 6 -	4.0	to	8.0	MHz
Band 7 -	8.0	to	16.0	MHa
Band 8 -	16.0	to	32.0	MHz

Accuracy: True frequency is within ±2% of indicated frequency, or within ±5 KHz, whichever is greater.

Voltage Measurement

Range: 0.01 uV to 1.0 V (160 dB); 60 dB on meter scale and 100 db of attenuator range.

Accuracy: ±2 dB for CW signals
±3 dB for impulse signals

Gain Flatness: Typically ±1 dB (25°C), maximum ±3 dB (-15° to 50°C).

Sensitivity

As a two-terminal RF voltmeter to produce a 3 dB meter indication above noise:

Narrowband CW Signal - Field Intensity Function:

	uV	dBuV	dBm
100 Hz bandwidth (0.01-32 MHz):	0.016	-36	-143
1 KHz bandwidth (0.01-32 MHz):	0.05	-26	-133
10 KHz bandwidth (0.02-32 MHz):	0.16	-16	-123

Broadband Impulse Signal - Direct Peak Function:

	dBuV/MHz	dBm/MHz
10 KHz bandwidth (0.01-0.014 MHz):	140	43
10 KHz bandwidth (0.014-0.02 MHz):	70	37
10 KHz bandwidth (0.02-32 MHz):	45	33
50 KHz bandwidth (0.07-32 MHz):	20	26

Detector

Field Intensity: Average value of output of the 60 dB logarithmic detector.

Quasi-Peak: Weighted average of output of the 60 dB logarithmic detector. Charge time is 1 millisecond; discharge time is 600 milliseconds.

Peak Function: Responds to true peak value. Calibrated in RMS of an equivalent sine wave. Selectable hold times of 0.05, 0.3, and 3.0 seconds.

Slideback Peak: Manual slideback detector with aural null indication.

BFO: Beat Frequency Oscillator. Nominal tone is 1 KHz.

2.3.2 Receiver, NM-37/57 EMI, Ailtech

Frequency

Range: 30 MHz to 1000 MHz in 8 bands.

Band 1 -	30	to	57	MHz
Band 2 -	55	to	105	MHz
Band 3 -	101	to	192	MHz
Band 4 -	186	to	292	MHz
Band 5 -	285	to	445	MHz
Band 6 -	430	to	620	MHz
Band 7 -	600	to	825	MHz
Band 8 -	800	to	1000	MHz

Accuracy: True frequency is within ±2% of indicated frequency.

Voltage Measurement

Range: 140 dB; 60 dB on meter scale plus 20, 40, 60, and 80 dB attenuator steps.

Accuracy: ±2 dB for CW signals
±3 dB for impulse signals

Gain Flatness: Typically ±2 dB (25°C),
maximum ±3 dB (-15°C to 50°C).

Sensitivity

As a two-terminal RF voltmeter to produce a 3 dB meter indication above noise:

Narrowband CW Signal - Field Intensity Function:

10 KHz Bandwidth

	uV	dBuV	dBm
Bands 1 through 3:	0.140	-17	-124
Bands 4 through 8:	0.316	-10	-117

1 MHz Bandwidth

	uV	dBuV	dBm
Bands 1 through 3:	1.40	3	-104
Bands 4 through 8:	3.16	10	-97

Broadband Impulse Signal - Direct Peak Function:

1 MHz Bandwidth

	uV/MHz	dBuV/MHz
Bands 1 through 3:	5.6	15
Bands 4 through 8:	10.0	20

Detector

Field Intensity: Average value of output of the 60 dB logarithmic detector.

Quasi-Peak: Weighted average output of the 60 dB logarithmic detector. Charge time is 1 millisecond; discharge time is 600 milliseconds.

Peak Function: Responds to true peak value. Calibrated to RMS of an equivalent sine wave. Selectable hold times of 0.05, 0.3, and 3.0 seconds.

Slideback Peak: Manual slideback detector with aural null indication.

BFO: Beat Frequency Oscillator. Nominal tone is 1 KHz.

2.3.3 Receiver, NM-67 EMI, Ailtech

Frequency

Range: 1.0 GHz to 18.0 GHz in 5 bands.

Band 1	-	1.0	to	2.0 GHz
Band 2	-	2.0	to	3.6 GHz
Band 3	-	3.6	to	7.6 GHz
Band 4	-	7.6	to	12.0 GHz
Band 5	-	12.0	to	18.0 GHz

Accuracy: True frequency is within ±1% of indicated frequency.

Voltage Measurement

Range: 1.0 uV to 1.0 V (120 dB): 60 dB on meter scale and 60 dB of attenuator range.

Accuracy: ±2 dB for CW signals
±3 dB for impulse signals

Gain Flatness: ±3 dB

Sensitivity

As a two-terminal RF voltmeter to produce a 3 dB meter indication above noise:

Narrowband CW Signal - Field Intensity Function:

Bandwidth	uV	dBuV	dBm
0.1 MHz:	2.2	7	-100
1.0 MHz:	7.0	17	-90
10 MHz:	22.0	27	-80

Broadband Impulse Signal - Direct Peak Function:

Bandwidth	uV/MHz	dBuV/MHz
0.1 MHz:	100	40
1.0 MHz:	31	30
10 MHz:	10	20

Detector

Field Intensity: Average value of output of the 60 dB logarithmic detector.

Special Peak: Responds to peak value with exponential decay.

Peak Function: Variable 5 millisecond to 3 second peak hold.

Slideback Peak: Manual slideback detector with aural null indication.

2.3.4 Receiver, Model 70078200, Alpha Industries

This receiver converts MMW RF signals from 26.5 to 40.0 GHz to an intermediate frequency (IF) range of 2.5 to 16.0 GHz. This resultant IF signal may be used to provide a source for a spectrum analyzel or similar equipment.

Frequency

Range: 26.5 GHz to 40.0 GHz

Accuracy: Within ±.11% of indicated frequency on direct reading frequency meter.

2.3.5 Receiver, Model 70088600, Alpha Industries

This receiver converts MMW RF signals from 93.5 to 97.5 GHz to an IF range of 4.0 to 8.0 GHz. This resultant IF signal may be used to provide a source for a spectrum analyzer or similar equipment.

Frequency

Range: Within ±.2% of indicated frequency on direct reading frequency meter.

2.3.6 Spectrum Analyzer, 8566B, Hewlett-Packard

Frequency

Range: 100 Hz to 22 GHz, dc coupled input.

Accuracy: Spans 5 MHz--
±2% of frequency span + frequency reference error x center frequency + 10 Hz.

Spans 5 MHz--
±2% of frequency span + n x 100 KHz + frequency reference error x center frequency, where n is the harmonic mixing number, depending upon the center frequency:

n	center frequency
1	100 Hz to 5.8 GHz
2	5.8 GHz to 12.5 GHz
3	12.5 GHz to 18.6 GHz
4	>18.6 GHz

Sensitivity

Measurement range is the total amplitude range over which the analyzer can measure signal responses. The low value is determined by sensitivity (10 Hz resolution bandwidth and 0 dB RF input attenuation) and the high value by damage level.

Range	Tuned Frequency Non-Preselected
- 95 dBm to +30 dBm	100 Hz to 50 KHz
-112 dBm to +30 dBm	50 KHz to 1 MHz
-134 dBm to +30 dBm	1 MHz to 2.5 GHz
	Preselected
-132 dBm to +30 dBm	2.0 GHz to 5.8 GHz
-125 dBm to +30 dBm	5.8 GHz to 12.5 GHz
-119 dBm to +30 dBm	12.5 GHz to 18.6 GHz
-114 dBm to +30 dBm	18.6 GHz to 22.0 GHz

Warm-up Time: Requires 30 minute warm-up from cold start, 0° to 55°C. Internal temperature equilibrium is reached after two hour warm-up at stabilized outside temperature.

2.3.7 Radiation Meter, Model 8616, Narda

Frequency

8621 Probe: 10.0 MHz to 300 MHz

8631 Probe: 300 MHz to 40.0 GHz; 95.5 GHz

Accuracy: Corrected Value = Raw Meter Reading x 1.122 + 3% of Full Scale x Correction Factor of the Probe

Response Time (Approx.): 1 Second in Fast
3 Seconds in Slow

Dynamic Range: 30 dB

Full Scale Ranges: (mW/cm^2)

Model 8621 and 8631 Probes
0 - 0.2
0 - 2.0
0 - 20.0

Power Density Alarm: An adjustable audible alarm pre-set by a panel control for a percentage of full scale.

Battery Type: 25 VDC rechargeable nickle-cadmium: 40 hours use time. 2.5:1 use to charge time.

2.3.8 Electromagnetic Leakage Monitor, Model 8201, Narda

Frequency: 2450 MHz

Accuracy: Corrected Value = Raw Meter Reading x 1.122 + 3% of Full Scale

Response Time (Approx.): 1.2 Seconds

Full Scale Ranges: (mW/cm^2)

Model 8221 Probe
0 - 0.2
0 - 2.0
0 - 20.0

Model 8223 Probe
0 - 1.0
0 - 10.0
0 - 100.0

Batteries: (2) Type 5.6 Volt NEDA 1404 that provide approximately 500 hours of operation.

3.0 EQUIPMENT AND PERSONNEL REQUIREMENTS

3.1 Maintenance Equipment Requirements

Oscilloscope -- Tektronix 7704A or equivalent

Oscilloscope -- Tektronix 7633 or equivalent

VOM Meter -- Simpson 260 (2)

3.2 Personnel Requirements

FCA is augmented by Timing/FCA personnel. One technician is required for mission support; two technicians are required for RF survey work.

4.0 GENERAL PROCEDURES

4.1 Perform preventive maintenance on FCA equipment daily, weekly, monthly, and yearly. Submit PM performance reports (cards) per SOP 003.005, Maintenance Management Program (MMP), and paragraph 7.0, of this procedure.

4.2 Perform corrective maintenance on FCA equipment as required and submit KTSRs per SOP 003.005, MMP, and according to the corrective maintenance procedures in the manufacturer's manual(s).

4.3 Provide realtime mission support as required by the mission schedule, the Vehicle Peculiar Supplement (VPS), and the FCA mission checklist, per Paragraph 8.0, of this procedure.

4.4 Perform RF surveys in accordance with USAKA approved test plans and reduce the survey data into useable engineering units.

4.5 Perform microwave oven surveys in response to requests from Macy's Department Store, USAKA and contractor safety offices, and island residents. At the end of each month, compile and submit completed microwave oven survey forms (Figure 3) to the Range Engineering Section secretary, who will include the surveys in the Range Engineering monthly report.

4.6 Submit weekly status reports to the E-Lab Supervisor, concerning O&M activities and significant events in FCA.

5.0 RF VAN OPERATIONAL PROCEDURES

5.1 Power Hook-up Procedures

Electrical power is supplied to the RF van through cables connected to either island power or the trailer-mounted diesel generator.

5.1.1 Island Power

Power drops (outlets) for the RF van are located on Kwajalein and Roi-Namur; on Kwajalein, the outlets are located at Buildings 988 (Calibration Lab) and 1721 (SR-1 Optics); on Roi-Namur, at Building 8063 (SR-5 Optics).

The interconnecting power cable used between the van and the outlet is located in the RF van storage container. Before connecting the power cable to the van, ensure that all ciruit breakers in the RF van, along with the air-conditioner control switch, are in the OFF position. Also, check to see that the diesel generator "LOAD" switch is in the OFF position.

After completing hook-up, engage air-conditioner first, then circuit breakers. Van equipment may then be turned on.

DATE: ____________

NAME: ____________

QUARTERS: ____________

PHONE NO.: ____________

MAKE: ____________

MODEL: ____________

SERIAL NO.: ____________

ELECTRICAL CHECKS:

FRONT: ________ mW/cm^2

SIDES: L ________ mW/cm^2

R ________ mW/cm^2

REAR: ________ mW/cm^2

MECHANICAL CHECKS:

--DOOR GLASS: ______

--HINGES: ______

--INTERLOCKS: ______

--SEALS: ______

--DAMAGED: YES / NO

--REMARKS: ____________

Check Performed By: ____________

DATE: ____________

NAME: ____________

QUARTERS: ____________

PHONE NO.: ____________

MAKE: ____________

MODEL: ____________

SERIAL NO.: ____________

ELECTRICAL CHECKS:

FRONT: ________ mW/cm^2

SIDES: L ________ mW/cm^2

R ________ mW/cm^2

REAR: ________ mW/cm^2

MECHANICAL CHECKS:

--DOOR GLASS: ______

--HINGES: ______

--INTERLOCKS: ______

--SEALS: ______

--DAMAGED: YES / NO

--REMARKS: ____________

Check Performed By: ____________

FIGURE 3. MICROWAVE OVEN DATA SHEET

5.1.2 Generator Power

For mobile and/or remote site operation, power can be supplied by the Onan 12 kilowatt, diesel generator.

If attached, disconnect the power cable described in 5.1.1; ensure that the diesel generator power cable is securely attached to the connector receptacle on the van.

Before starting the generator, ensure that all circuit breakers in the RF van, along with the air-conditioner control switch, are in the OFF position. The procedure for starting the generator is as follows:

1. Check fuel supply.
2. "LOAD" switch OFF.
3. Engage "PREHEAT" switch for 60 seconds.
4. Engage "START" switch.
5. "LOAD" switch ON.
6. If engine fails to start after 20 seconds, repeat steps 2 & 3 above.

After generator is started, check voltage and frequency meters for proper indications (230 VAC, 60 Hertz); engage airconditioner first, then circuit breakers. Van equipment may then be turned on.

5.1.3 Power-down Procedure

Before removing power, the following procedure is followed:

1. All equipment and air-conditioner "OFF".
2. All circuit breakers "OFF".
3. If generator is used, immediately place LOAD switch to "OFF".

5.2 Communications Hook-up Procedure

Electronics Net (E-Net) and telephone communications are supplied to the RF Van through a cable to communications hook-ups at the buildings listed in 5.1.1. An additional hook-up is located at the telemetry facility on Roi-Namur (T-5).

A communications cable is located in the RF Van storage container; cables are in place at the SR-1 and T-5 facilities.

5.3 RF Van Antenna Mast Operating Procedures

5.3.1 Raising Mast

1. CONTROL VALVE to "~~HOLD~~".
2. All locking collars, with the exception of the top one, should be tightened by turning the locking screws clockwise.
3. Set MAIN VALVE on pneumatic system to "ON" (pull out).
4. OPERATING HANDLE to "UP" to desired height.

5.3.2 Lowering Mast

1. OPERATING HANDLE to "DOWN".
2. When air is released, unclamp the lowest collar and let the lower section fully retract.
3. OPERATING HANDLE to "HOLD". As mast lowers, repeat Step 2 until fully retracted.

NOTE: For more information, refer to the AL-750 O&M Manual.

6.0 RF SURVEY PROCEDURES

6.1 Narda Model 8616 Monitor Description

Used for most RF survey power density measurement work, the Model 8616 is a Broadband Isotropic Radiation Monitoring System covering a frequency range from 300 KHz to 95 GHz, with only three probes. The unit is battery-operated from an internal, rechargeable battery. The unit can also be operated from AC mains of 115 or 230 VAC. An auto zero function permits the unit to be zeroed by pressing the switch on the handle. In addition to its normal mode of operation (where instantaneous indications of the monitored field are displayed), a "MAX HOLD" mode is provided. In this mode of operation, the maximum power density surveyed will be indicated and maintained until the "AUTO-ZERO" switch is pressed. Refer to Section II of the 8616 O&M Manual.

6.1.1 Data Sheets

RF survey measurement data is recorded on data sheets (Figures 4 & 5). As a general rule, Figure 4 is used when a drawing of the survey site accompanies the completed report, while the remarks section of Figure 5 can detail pertinent measurement location information.

EMITTER NAME__________ PAGE_____ OF_____

FREQUENCY__________ CORRECTION FACTOR__________ PEAK POWER_____

AVERAGE POWER__________ PULSE WIDTH__________ PRF_____

* - MEASUREMENT TAKEN AT LESS THAN FULL POWER; EXTRAPOLATED TO FULL POWER

SITE NUMBER	LOCATION	MEASUREMENT HEIGHT (FT)	EMITTER AZIMUTH (DEG)	EMITTER ELEVATION (DEG)	RAW METER READING IN mW/CM^2	CORRECTED METER READING IN mW/cm^2	EXTRAPED TO FULL POWER IN mW/cm^2

FIGURE 4. RF SURVEY DATA SHEET

EMITTER NAME__________ PAGE_____ OF_____

FREQUENCY__________ CORRECTION FACTOR__________ PEAK POWER_____

AVERAGE POWER__________ PULSE WIDTH__________ PRF__________

* - MEASUREMENT TAKEN AT LESS THAN FULL POWER; EXTRAPOLATED TO FULL POWER

	RAW METER READING IN mW/CM^2	CORRECTED METER READING IN mW/cm^2	EXTRAPED TO FULL POWER IN mW/cm^2

FIGURE 5. RF SURVEY DATA SHEET

6.1.2 Data Correction

Data as measured are listed in the "RAW METER READING" column of the data sheets. The "RAW" data is then corrected for the manufacturer's stated possible error (+0.5 dB + 3% of full-scale reading) and multiplied by the probe frequency calibration factor (listed on the probe handle or attached card), and listed in the "CORRECTED METER READING" column. An example follows:

Raw Meter Reading	=	0.110
+0.5 dB	=	x 1.122
		0.12342
+3% Full-scale (.03 x 0.2 = .006)	=	+ 0.00600
		0.12942
Calibration Factor @ 415.0 MHz w/8621B Probe P/A#1004897P-02	=	x 1.23100
		0.159

0.159 is the corrected value.

If the transmitter being surveyed radiates at less than full power, the "CORRECTED METER READING" is multiplied by the extrapolation factor. This product is then entered in the "EXTRAPED TO FULL POWER" column. For example, if the transmitter radiates at half-power (50% = 0.5), the extrapolation factor is 2, which is the reciprocal of 0.5. For further information, refer to the 8616 O&M manual.

6.2 Ailtech NM-17/27, NM-37/57, & NM-67 Receivers

The Ailtech receivers are field intensity meters that can be used for narrowband RF signal measurements. The start-up procedure for making RF measurements is as follows (for further information, refer to the appropriate receiver O&M manual:

1. Turn on receiver to be used.
2. Calibrate receiver as per instructions.
3. Select frequency to be measured.
4. Prepare receiver for measurements (i.e., attenuator, bandwidth, measurement function, etc.).
5. Select and position proper antenna for receiving.
6. Connect RF cable (e.g., RG-214) from antenna to RF patch panel connector "A" (Type-N female).
7. Connect RF cable from RF patch panel connector 52 to RF input of receiver.
8. Proceed with measurements.

After completing measurements, correction for line-losses, antenna factor, and receiver attenuator, must be computed. The pre-mission PM check contained in 8.2 can be used as a guide. Antenna correction factor charts are located in the RF Van and the FCA office.

6.3 Spectrum Signature Recording System

The RF Van has the capability of recording any data observed on the HP-8566B spectrum analyzer in a hard copy by the HP-7225A plotter or the HP-9866A printer. The system uses an HP-9825A computer for manual or automatic control of the recording process. The RF input to the spectrum analyzer makes use of the same signal path used for the Ailtech field intensity meters.

The procedure for making recordings is as follows:

1. Turn on spectrum analyzer, plotter, and printer.
2. Load data cartridge labeled "SPECTRUM SEARCH" into computer.
3. Turn on computer -- observe spectrum analyzer display.
4. Using spectrum analyzer keypad, select "5 -- Spectrum Analyzer Automatic Calibration".
5. Follow instructions on computer display.
6. If automatic checkout is not available, the spectrum analyzer can be manually calibrated. Select "RECALL" and "8" on the front panel. Adjust "AMPTD CAL" for a -10 dBm signal level. Next, select "RECALL" and "9". Adjust "FREQ ZERO" for maximum amplitude. Lastly, select "SHIFT" and "w" ("FREQUENCY SPAN" button), to initiate the internal calibration program.
7. Using spectrum analyzer keypad, select "2 -- Spectrum Search (Automatic)", or "6 -- Transfer CRT to Plotter (Manual)".
8. Follow instructions on computer display.

6.4 Alpha Industries Millimeter Wave (MMW) Receivers

The Alpha MMW receivers downcovert K and M band RF signals to intermediate frequencies that can be processed in the RF van. The system consists of two sets of receivers, radomes, and waveguides. Each set provides coverage for either K or M band -- not both. A Watkins-Johnson antenna controller and antenna are used for signal capture.

For further information, consult the appropriate O&M manual.

6.5 Narda Model 8201 Monitor Description

Used for microwave oven RF survey power density measurement work, the Model 8201 is an Electromagnetic Leakage Monitor calibrated at 2450 MHz. The unit is battery-operated from an internal battery. The unit is zeroed by adjusting a control knob. The measurement range is selected by a three-position switch. A styrofoam spacer on the end of the probe provides the user with a set measurement distance during the measurement process.

For further information, consult the O&M manual.

7.0 PREVENTIVE MAINTENANCE (PM)

7.1 General

All performance/completion of PM routines will be reported per SOP 003.005, Maintenance Management Program.

7.2 Schedule

PM is performed in accordance with the PM Recall List, which is issued semi-annually. PM checks are performed according to the manufacturer's recommendations.

8.0 MISSION OPERATIONAL PROCEDURE

During Range operations, the RF Van will primarily support from either Kwajalein or Roi-Namur. Support location requirements must be determined at least two weeks in advance should transportation be required. Transport is arranged by informing the PRC Kentron Transportation Coordinator at X1529.

Procedures for reporting and evaluating information concerning incidents of suspected meaconing, intrusion, jamming, and interference, are contained in Annex II (AR 105-3).

All FCA activities must be entered into the RF Van Logbook.

8.1 Mission Activity T-2 and T-1 Days

Verify operation of communications hook-up during E-Net communications/status check. Conduct pre-mission preventive maintenance checks listed in paragraph 8.2.

8.2 Mission Day Activity

Man the RF Van at the specified time for operation (generally, four hours prior to the opening of the mission window).

The following pre-mission preventive maintenance check will provide the operator with a means to verify the operation of the RF signal path to the spectrum analyzer and the EMI/FI receivers:

1. Connect HP-10502A cable between the "CAL OUTPUT" and "RF INPUT" of the HP-8566B spectrum analyzer.
2. Follow spectrum analyzer checkout procedure outlined in 6.3.
3. Connect 10-foot RG-214 RF cable between "CAL OUTPUT" of the spectrum analyzer and RF Van patch panel connector 52.
4. Connect 50-foot RG-214 RF cable between RF Van external RF patch panel connector A and the RF cable connected to the Tecom log-periodic antenna.
5. Turn on RF Van antenna selector and select "R1-2".
6. Using the "SPECTRUM SEARCH" tape, select "6 -- Transfer CRT to Plotter" and run a plot of the observed signal. If plotter capability is not available, note power level difference from the -10 dBm calibration signal.
7. System attenuation should not exceed -15 dB (-12.5 db nominal).

APPENDIX E

NAVAL WEAPONS CENTER

CHINA LAKE, CALIFORNIA

NAVAL WEAPONS CENTER

CHINA LAKE, CALIFORNIA

FREQUENCY MONITORING CAPABILITIES

CODE 62203

I. FIXED FACILITY

A. Monitoring and surveillance - 0.5 to 18 GHz.

B. Direction finding (DF) - 140 MHz to 18 GHz.

C. Pulse analysis

Frequency, width, amplitude, PRI/PRF.

D. Spectrum analysis - 0.5 to 18 GHz.

E. Validation of target set-up and calibration.

F. Hardcopy of pulse and frequency characteristics.

II. MOBILE FACILITY

A. Monitoring and surveillance - 0.5 to 18 GHz.

B. Direction finding (DF) - 140 MHz to 18 GHz.

C. 'On-site' monitoring and surveillance.

D. Pulse analysis

Frequency, width, amplitude, PRI/PRF.

E. Interference tracking - 0.5 to 18 GHz.

F. General project/test support validation for remote target set-up and calibration.

G. Hardcopy of pulse and frequency characteristics.

H. Spectrum analysis - 0.5 to 18 GHz.

NOTE: Provision for 18-40 GHz and 30-500 MHz coverage is included in the Microtel MSR-904A surveillance receiver of the mobile facility.

III RANGE OPERATIONS INSTRUMENTATION CODES

A. H(F) - Lark Hill Fixed Frequency Monitoring Facility

B. H(M) - Mobile Frequency Monitoring Facility

MOBILE VAN INSTRUMENTATION SYNOPSIS

I. SPECTRUM ANALYZER, TEKTRONIX TYPE 494P

A. IF bandwidths of 30 Hz, 100 Hz, 1 KHz, 10 KHz, 100 KHz, and 1 MHz.

B. Built in frequency counter to 325 GHz.

C. Nonvolatile memory storage.

D. Keypad data entry.

E. Direct Plot capability

F. Display can be normal or digitally refreshed.

G. Present antenna system supports coverage from .14 - 18 GHz.

H. IEEE-488 interface capability is incorporated into the system.

II. MICROWAVE RECEIVER, MICROTEL TYPE MSR 904A

A. Present antenna system supports coverage from .14 - 18 GHz.

B. IEEE-488 is not available but system has remote control capability.

C. System is controlled via an IEEE-488 interface in the Microtel FCS-904 frequency/counter synthesizer unit.

D. IF outputs consists of 160MHz and 21.4 MHz.

E. IF bandwidths of 100 KHz, 1 MHz, 5 MHz, and 30 MHz are standard.

F. Scan limits anywhere within the selected band are set with the F1 and F2 controls, resulting in scanning of single, full, crossband and external scan control.

G. Video consists of log and linear AM/FM.

H. Tuning can be fixed or delta over an adjustable percentage of the current band in use.

III. FREQUENCY COUNTER/SYNTHESIZER, MICROTEL TYPE FCS 904

A. Modes of operation to control MSR 904A receiver.

1. Fixed frequency synthesized
2. Linear scan.
3. Synthesized step scan.

B. Linear scan mode can be used to identify signals in the auto-stop mode.

C. Unit incorporates IEEE-488 capability.

IV. DIGITALLY REFRESHED DISPLAY, MICROTEL TYPE DC-904

A. IEEE-488 interface is not available, control is accomplished by the FCS 904 interface.

B. Depending on the mode of operation, signals are accepted from the MSR 904A or the FCS 904.

C. The pan display mode provides demodulation of the 160 MHz and generates a 20 MHz wide sweep.

D. Signals from the MSR 904A in the multi-band mode, provide 5-trace display capability.

V. PULSE ANALYZER, SCI-COM Type SCP 2160A

A. Pulse signals are analyzed on a pulse-pulse basis with a maximum of 256 pulses per read cycle.

B. Unit is equipped with a constant read mode.

C. Pulse analyzer will accept either 160 MHz IF or demodulated video input

D. To determine how many times a particular PRI had occurred, the de-interleave mode will process the pulse data then display on the CRT the location of the PRI/S by use of a cursor which identifies both pulse and memory locations.

E. In the de-interleave and constant read mode, the signal/s to be processed must fall within operator set limits of amplitude and center frequency.

F. Pulse analyzer is equipped with IEEE-488 interface.

VI. OSCILLOSCOPE DIGITAL TEKTRONIX TYPE 2430A

A. Unit has a 150 MHz bandwidth with 5 ns/div maximum sweep speed.

B. Provides digitizing rate of 100 Megasamples/sec with 8 bit resolution.

C. Simultaneous acquisition of two channels.

D. Fully GPIB programmable for systems and automated test applications.

E. SAVE on Delta feature to capture and save events that deviate from user selected limits.

F. Full screen readout and extensive cursor functions.

G. Triggering functions include; delay by time, delay by events, and two external trigger inputs.

H. Six waveforms can be saved for later display, analysis, and comparison.

I. Acquisition modes consist of repetitive and non-repetitive (normal mode); envelope mode records and displays min and max waveform values over one or more sweeps.

J. Provide direct hard copy output via GPIB (IEEE-488) to a plotter/printer.

VII. CONDOR ANTENNA CONTROL

A. Adjustable sector scan or fixed antenna positioning within one tenth of a degree is accomplished by this unit.

B. Unit will rotate companion antenna at speeds of 1-200RPM.

C. Unit will present automatic DF on companion display in both rotational and sector scan modes.

D. IEEE-488 is available.

VIII. COMPUTER, HEWLETT-PACKARD TYPE 9836, MODEL 236

A. 512K memory plus operating language (basic).

B. Dual disk drive (5 1/4 inch disk).

C. Monochrome CRT (12").

D. Integrated keyboard.

E. 128K byte internal ram.

F. HP-IB interface.

G. 8 MHz processor board.

H. 8-slot backplane.

I. Supports up to 2.05M byte ram.

IX. PLOTTER GRAPHICS, HEWLETT-PACKARD TYPE 7470A.

A. 2-PEN/2 color plotting.

B. IEEE-488 interface.

C. Supports graphics software packages for HP computers.

X. PRINTER, HEWLETT-PACKARD TYPE 2671G

A. Graphics printer.

B Interfaced to the HP-9836 computer.

C. Standard column parameters.

XI. GENERATOR, ONAN EMERALD

A. 6.5 KW.

B. Recessed into interior of mobile van.

C. Fully remote capability is incorporated.

D. Single phase.

XII. AIR CONDITIONER, DURATHERM

A. 3.5KW

B. Recessed into interior of mobile van.

FIXED FACILITY INSTRUMENTATION SYNOPSIS

I. WATKINS-JOHNSON 1840 WIDEBAND RECEIVING SYSTEM

A. Frequency range 0.5 to 18 GHz

B. Selectable Bandwidths up to 500MHz

C. Frequency data is written directly on the face of CRT in numeric form.

D. Provide superhet receiver sensitivity and selectability.

E. IF or RF blanking.

F. Digitally refreshed or storage display.

G. Permits band scan, limit scan, and manual modes of operation. Also provides for intercept, dwell, and dependent modes.

H. Synchronizer compatibility.

II. WATKINS-JOHNSON 8971A DIRECTION FINDING SYSTEM

A. Frequency range 20-1000MHz.

B. LED bearing indication - no CRT

C. Accuracy 1 degree RMS

D. Built in calibration.

E. Pseudo doppler system

F. IF input frequency 21.4MHz.

III. EMTEL MODEL 7200B 3-AXIS DISPLAY

A. Displays in a real-time visual format, the time varying, frequency - varying, amplitude - varying properties of signals and noise in blocks of spectrum space.

IV. MICROTEL WR-550C DIRECTION-FINDING SYSTEM

A. Frequency range 3KHz - 100 GHz.

B. Frequency counter

V. WATKINS-JOHNSON 8730 VHF/UHF RECEIVER

VI. WATKINS-JOHNSON 8617B VHF/UHF RECEIVER

VII. RACAL TAPE RECORDER

VIII. MICROTEL MSR 904A MICROWAVE RECEIVER

A. See Mobile Van Synopsis

IX. FREQUENCY COUNTER/SYNTHESIZER, MICROTEL TYPE FCS 904

A. See Mobile Van Synopsis

X. DIGITALLY REFRESHED DISPLAY, MICROTEL TYPE DC-904

A.See Mobile Van Synopsis

XI. PULSE ANALYZER, SCI-COM 2160A

A. See Mobile Van Synopsis

XII. CONDOR ANTENNA CONTROL

A. See Mobile Van Synopsis

XIII. TEKTRONIX 4631 HARD COPY UNIT

XIV. SYSTRON DONNER 5103 DIGITAL PRINTER

XV. OSCILLOSCOPE TEXTRONIX TYPE R7613

A. Direct writing on the display is accomplished by the 7M13 readout mode.

B. Scope is capable of dual trace without the 7M13 readout and addition of amplifiers.

C. Scope has time base and vertical amplifier gain settings on display.

D. Vertical amplifier has 100 MHz bandwidth.

XVI. HEWLETT-PACKARD 141T SPECTRUM ANALYZER DISPLAY.

XVII. HEWLETT PACKARD 7475A/6 PEN PLOTTER

XVIII. ANTENNA SYSTEMS

A. AN/APA 69A (2) /1-12.4 GHz

B. TECOM / .5-18 GHz.

C. AEL Crossplanner Log Periodic / 100Hz - 1GHz.

D. ANDREWS (2) /300 - 3000 MHz.

XIX. FY88/89 MOBILE/FIXED SURVEILLANCE ENHANCEMENTS

A. Hewlett-Packard 8566B spectrum analyzer and associated software will replace Tektronix 494P spectrum analyzer presently in mobile van. The 494P will in turn be used in the fixed site.

B. Hewlett-Packard HP9000 Model 330C color workstation will replace existing HP9836, Model 236 in mobile van. In turn, the HP 9836 will be used in the fixed site.

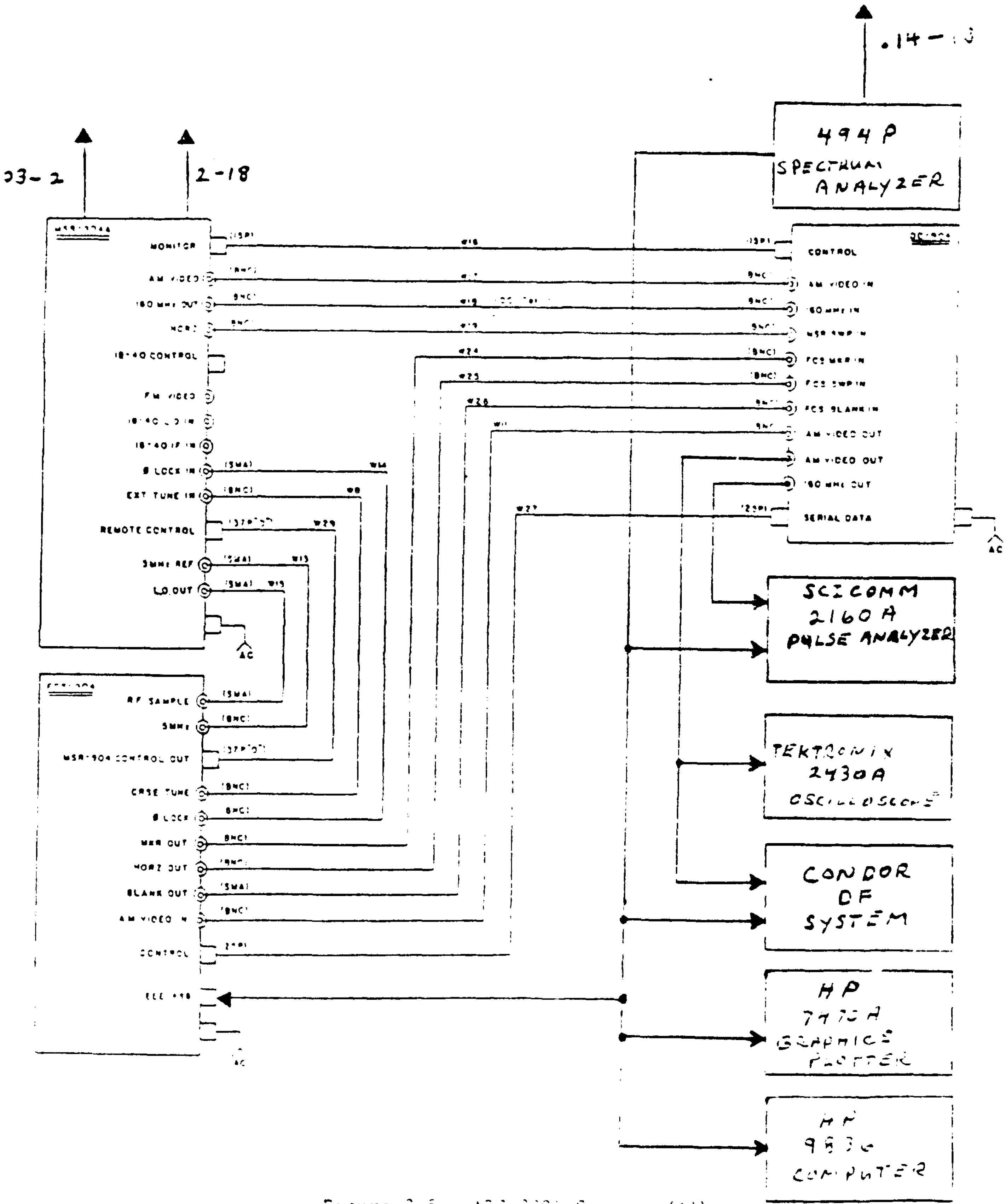
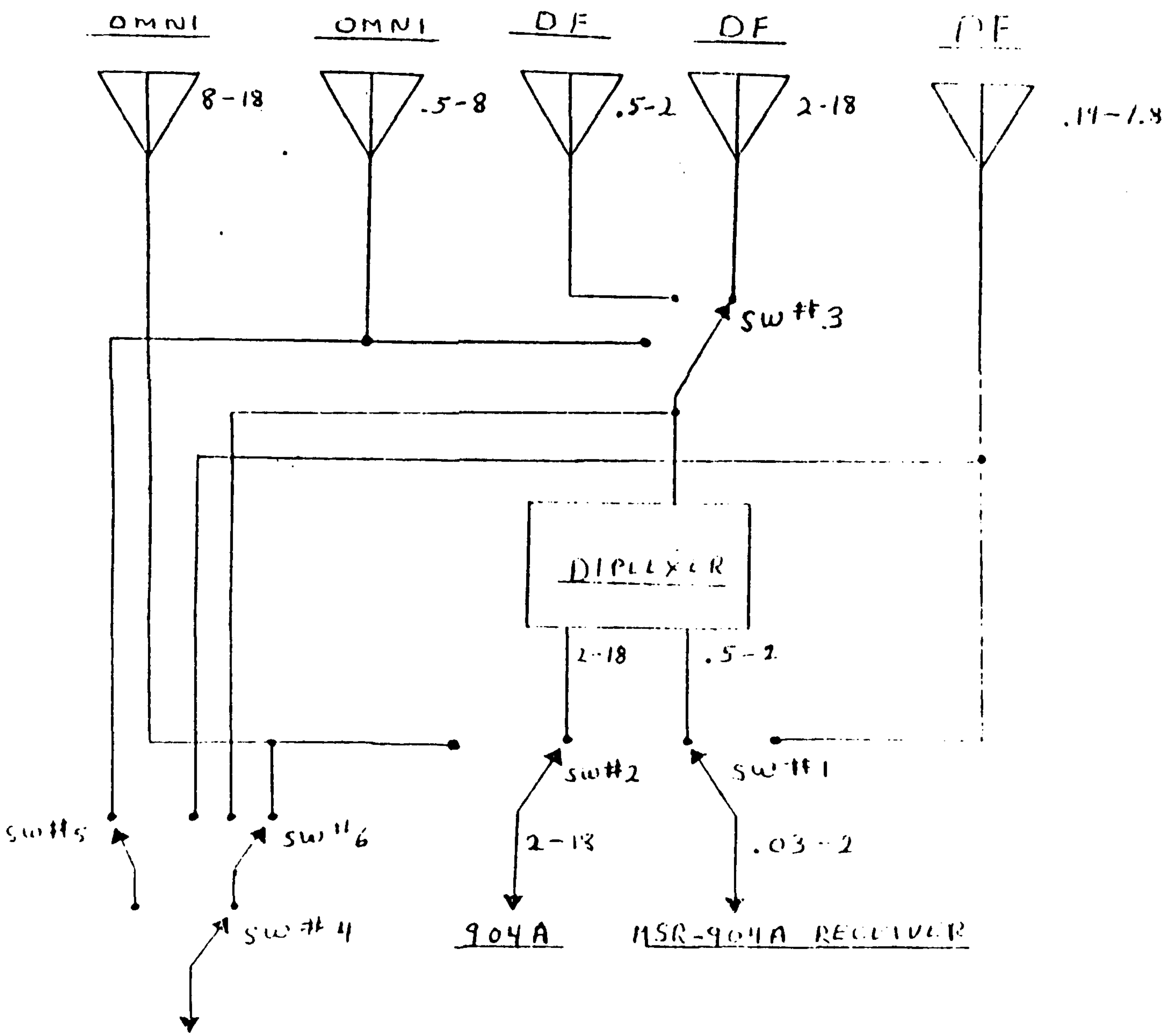
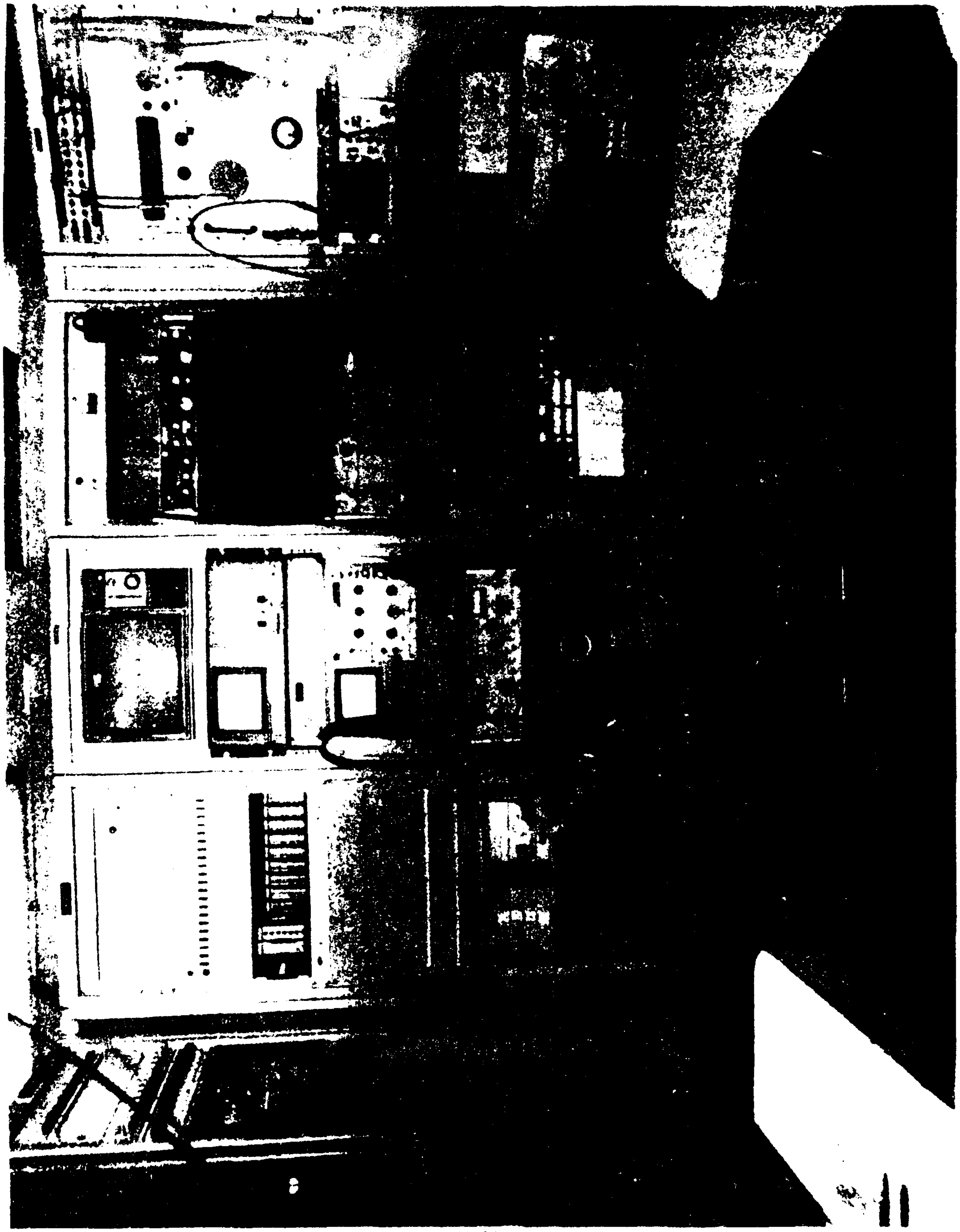
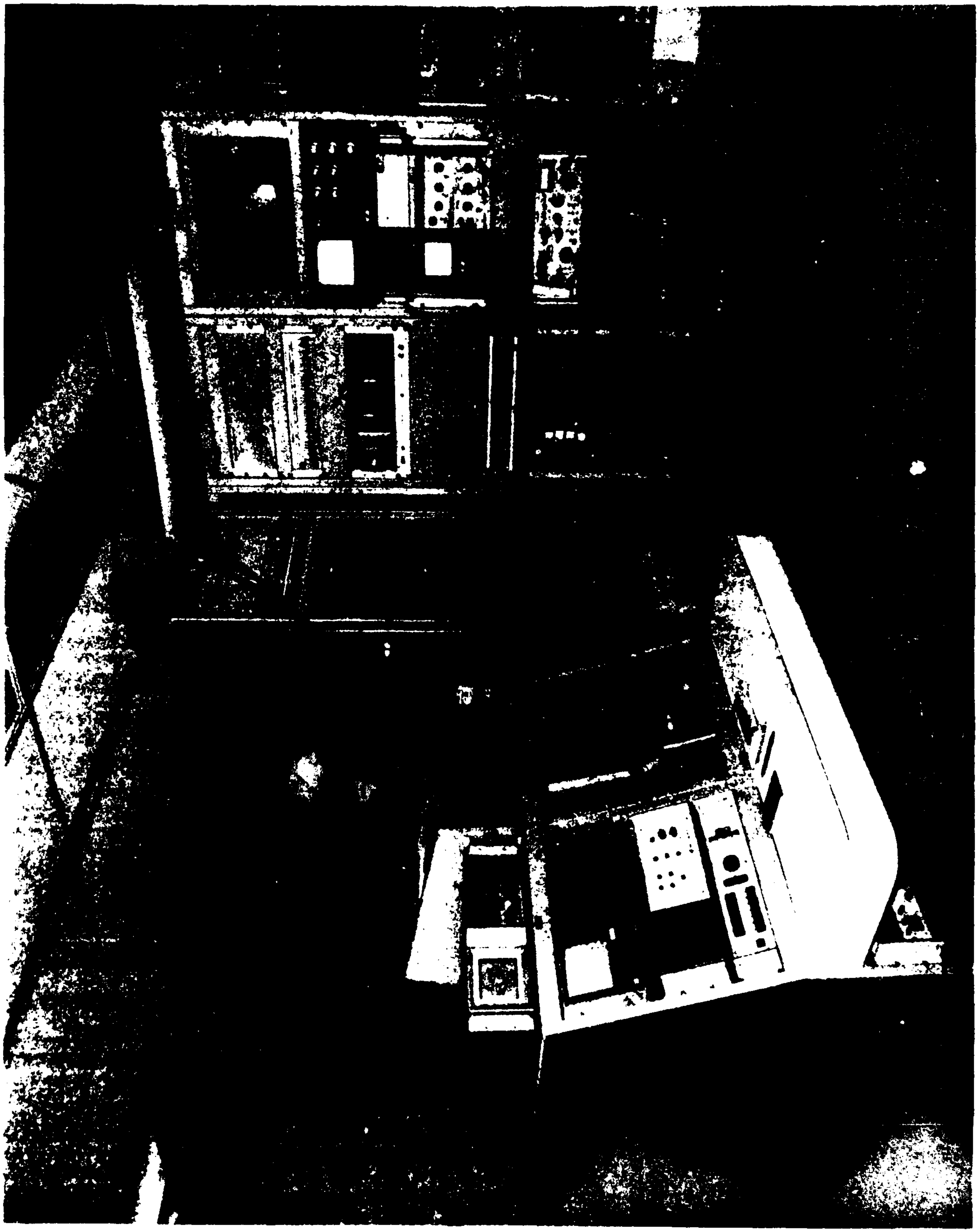


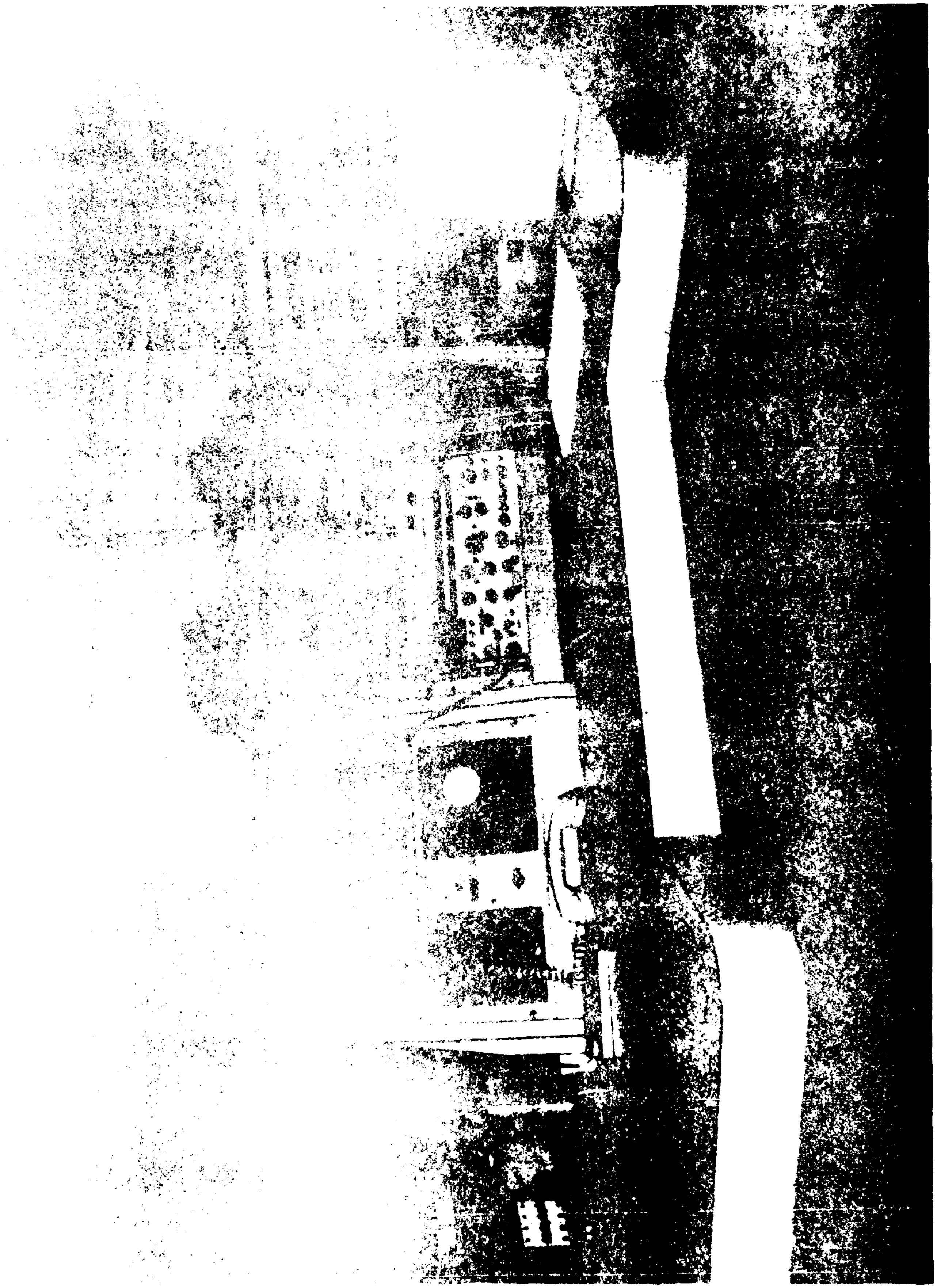
Figure 2.5. ARS-2904 System (A1)
Interconnection Diagram 92B10-091

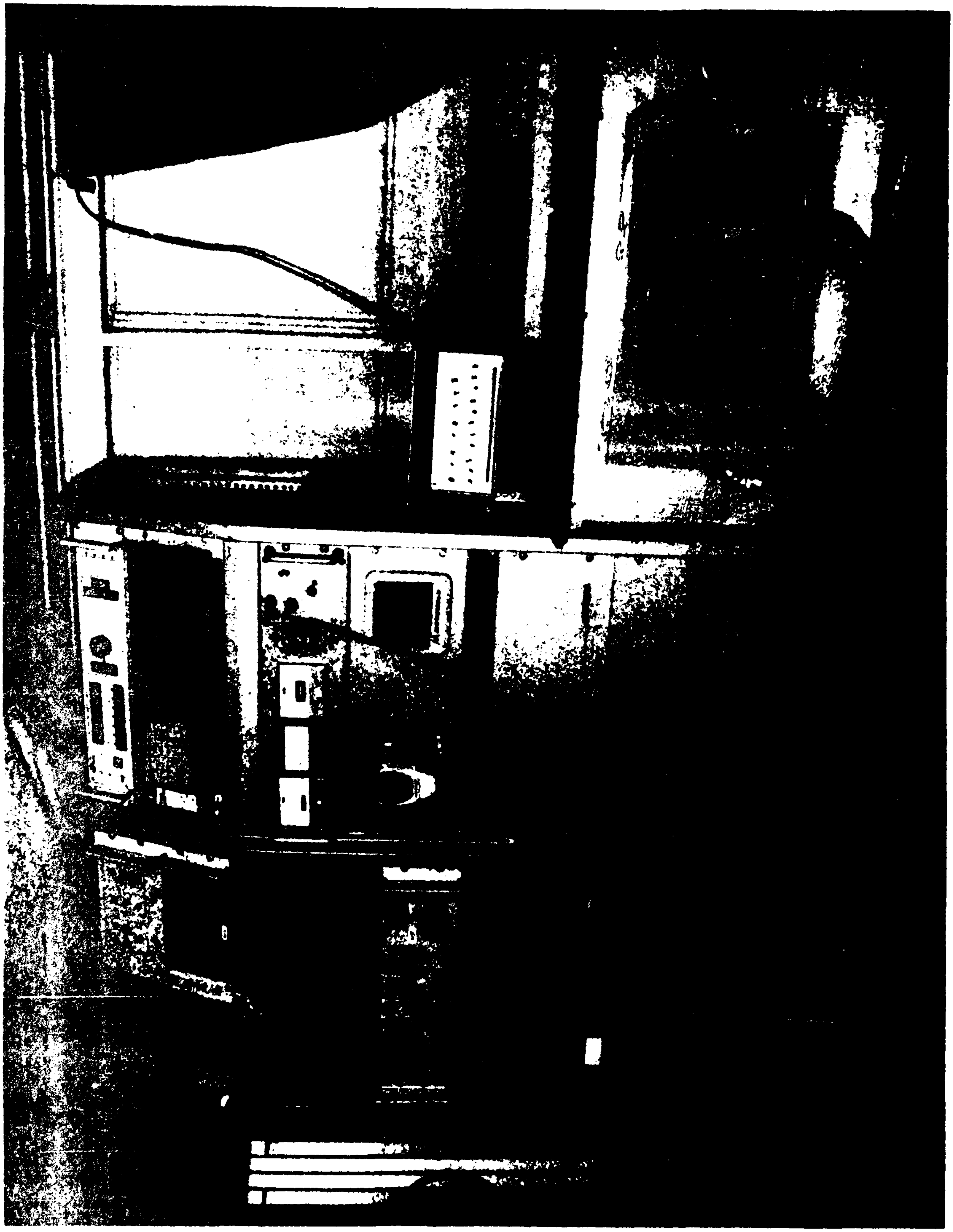
MOBILE VAN ANTENNA SWITCHING

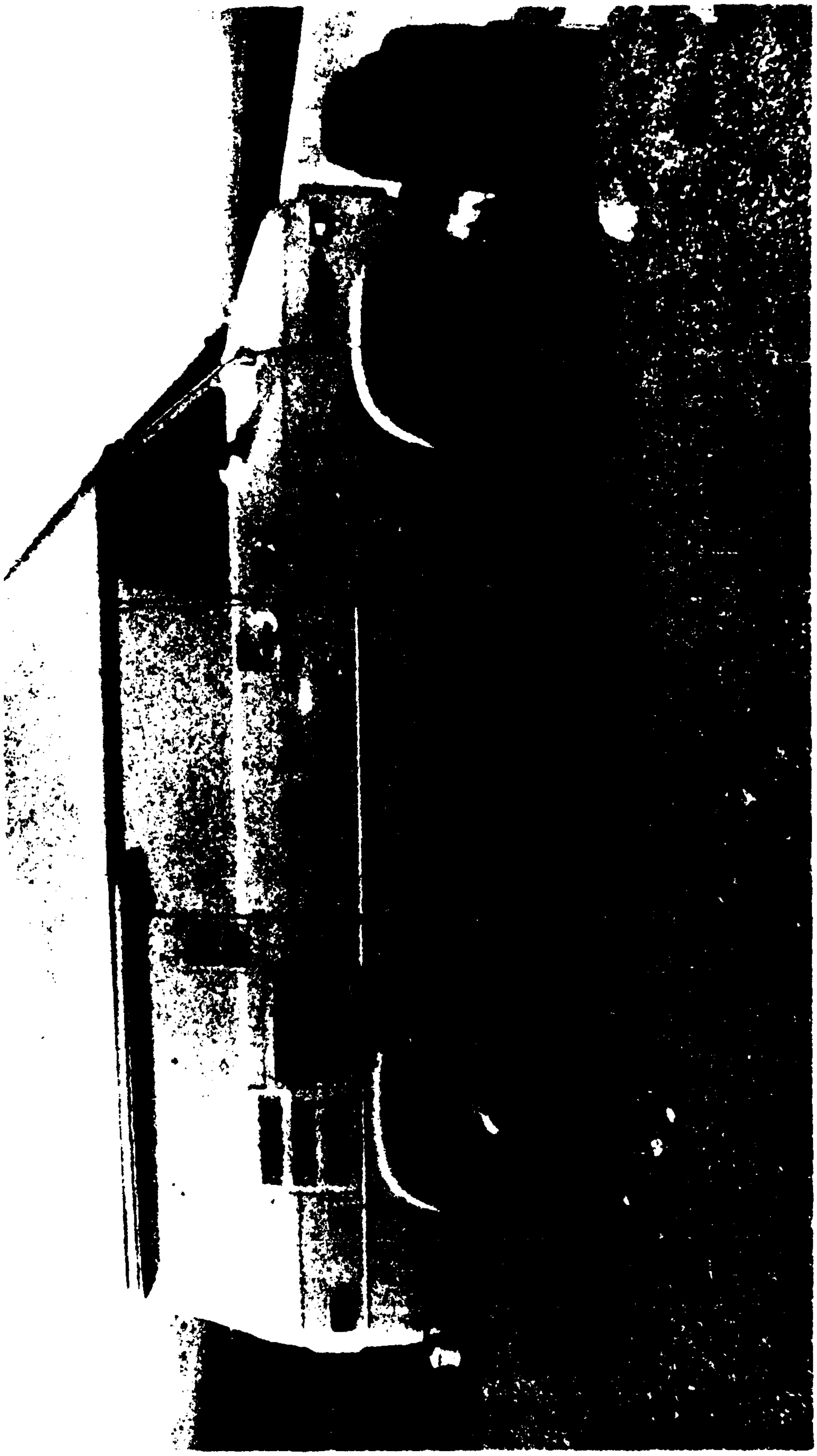


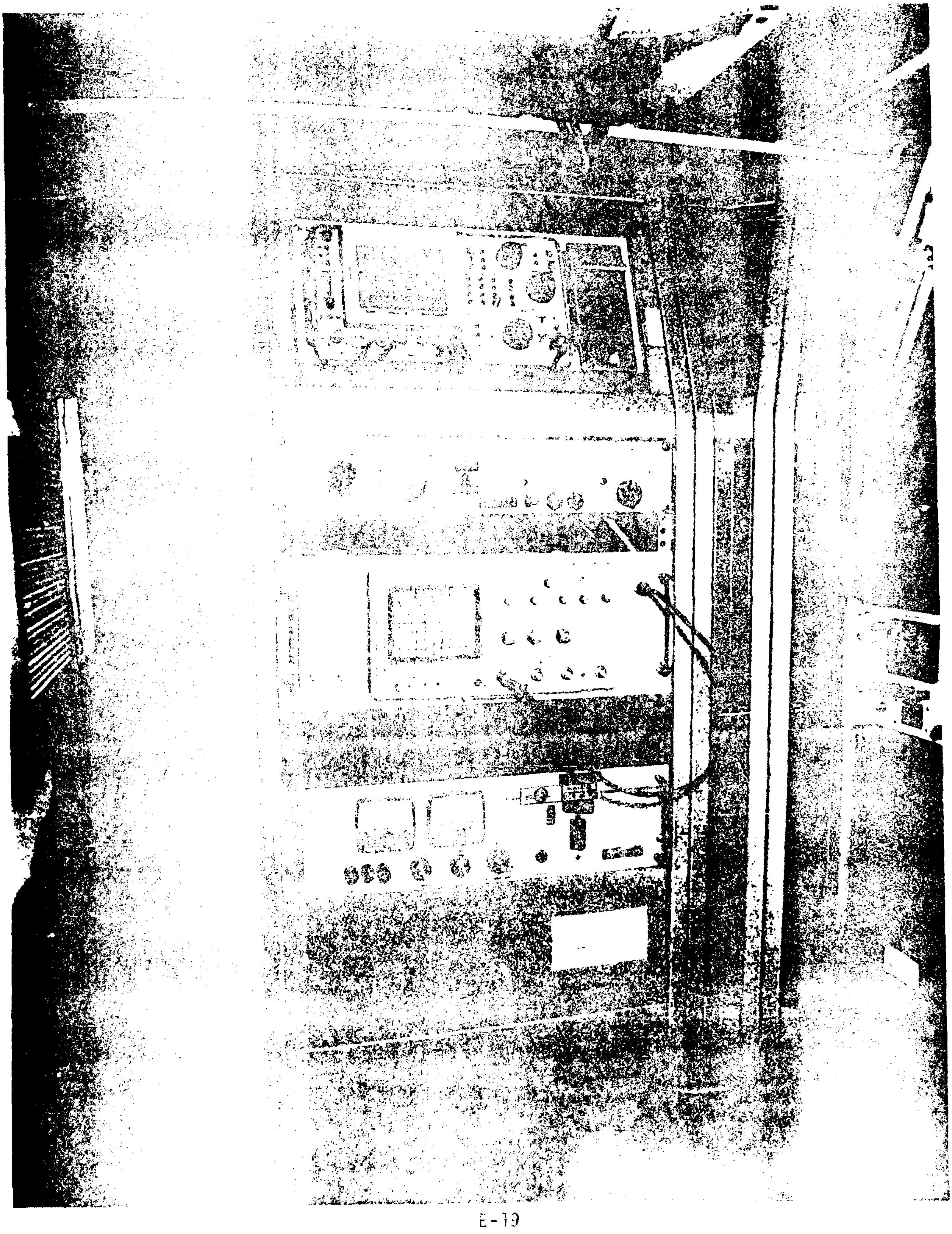












APPENDIX F

TACTICAL FIGHTER WEAPONS CENTER
NELLIS AIR FORCE BASE, NEVADA

CHAPTER 10

SAS BASELINE CONFIGURATION AND SIGNAL MEASUREMENT CAPABILITIES

The SAS, as defined within this document, is a technical intelligence acquisition system. Its configuration of manual and computer controlled digital/analog systems with associated antennas provide a capability for measurement, evaluation, and analysis of radars, simulators, electronic countermeasures and communications signals, during operational test/evaluation/training exercises. Inherently, the SAS supports special operational missions and area frequency management.

The contractor, in concert with the United States Air Force, provides a comprehensive technical service which exploits the SAS electromagnetic surveillance capabilities to the maximum extent possible and generates timely evaluation and performance analysis of the electronic combat systems for the Nellis Range Group. These data products and format must be responsive to airborne operations, engineering design, and specifications of systems under test.

The SAS consists of the following major functional elements:

a. A roof-mounted antenna system capable of collecting electromagnetic signals over the frequency bands from 30 MHz to 18 GHz.

b. Receivers capable of resolving, detecting, and measuring the frequency and time domain modulations of radars, jammers, and communication emitters. The SAS utilizes two independent and parallel receiver systems: a Hewlett-Packard (HP) ARS400 spectrum analyzer with associated time domain log video detectors; and an HP 8566B spectrum analyzer. (Time domain detectors may be added to the HP 8566B).

   (1) These two receiver systems are complementary in terms of instantaneous bandwidth, frequency resolution and ability to measure a wide variety of modern signal modulations. The HP spectrum analyzer instantaneous bandwidth is controllable from a maximum of less than 8 MHz to 10 Hz. By its nature, as a swept superheterodyne with narrow filters, it is capable of high fidelity precise spectrum analysis of stable, repetitive signals.

   (2) The HP 8566B receiver system has higher frequency resolution and is used to provide a more graphic data product. This receiver system provides an input to the on-board video recording system and provides a means for continuously recording as events occur.

c. A video tracking and HP 8566B receiver recorder system capable of manual or video tracking of airborne targets by utilizing either of two video cameras.

An installed video recorder system on demand compositely records all tracked target data along with HP8566B receiver data for aircrew feedback and analysis.

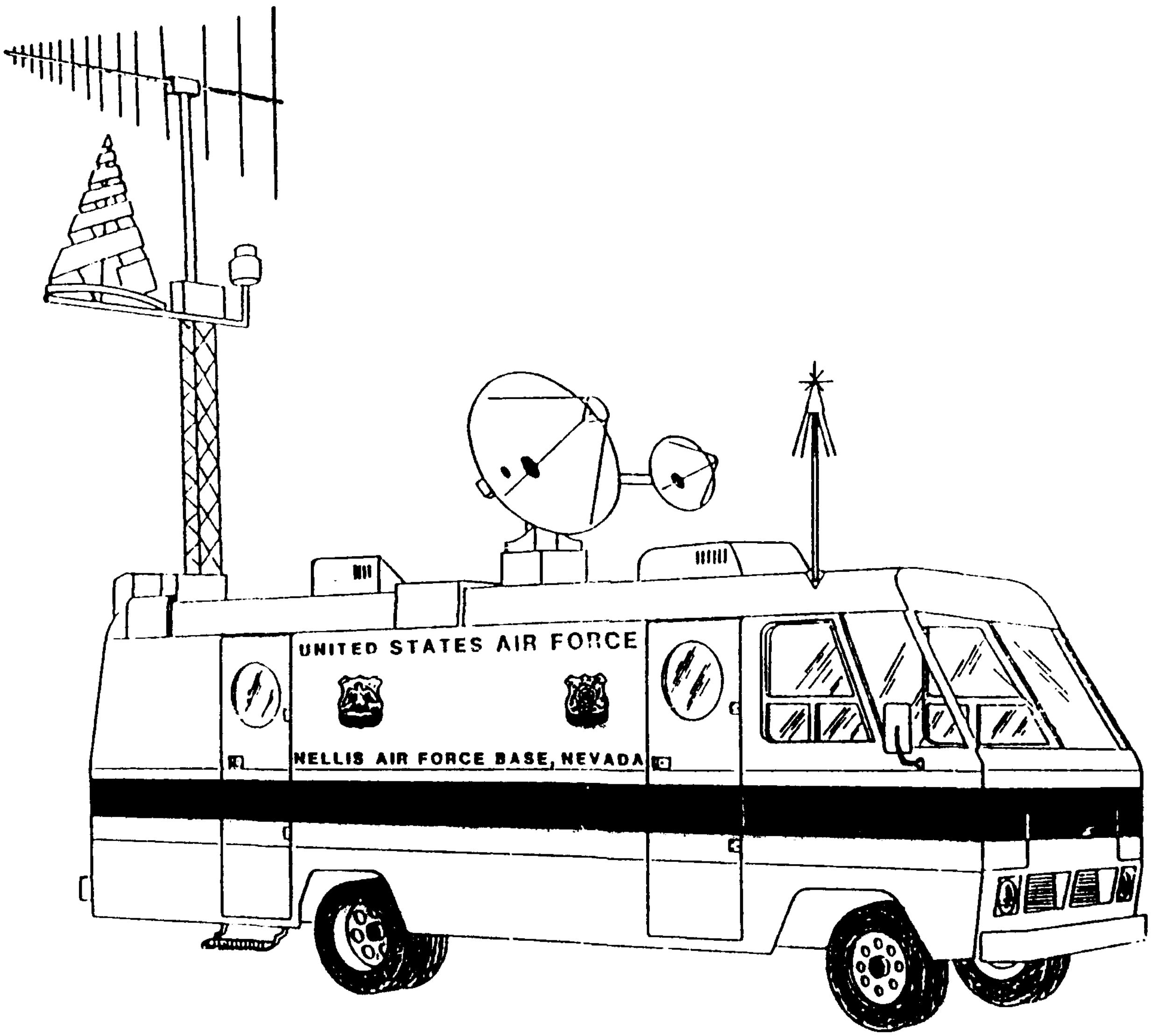
d. HP 2100s computer system: The SAS is potentially capable of realtime automated control. The Hewlett Packard System is interconnected via an HPIO bus. All SAS equipment is designed for digital input/output functioning, although the equipment is basically analog and would need additional equipment and programming to perform realtime output.

e. The three operator/control stations and their functions are as follows:

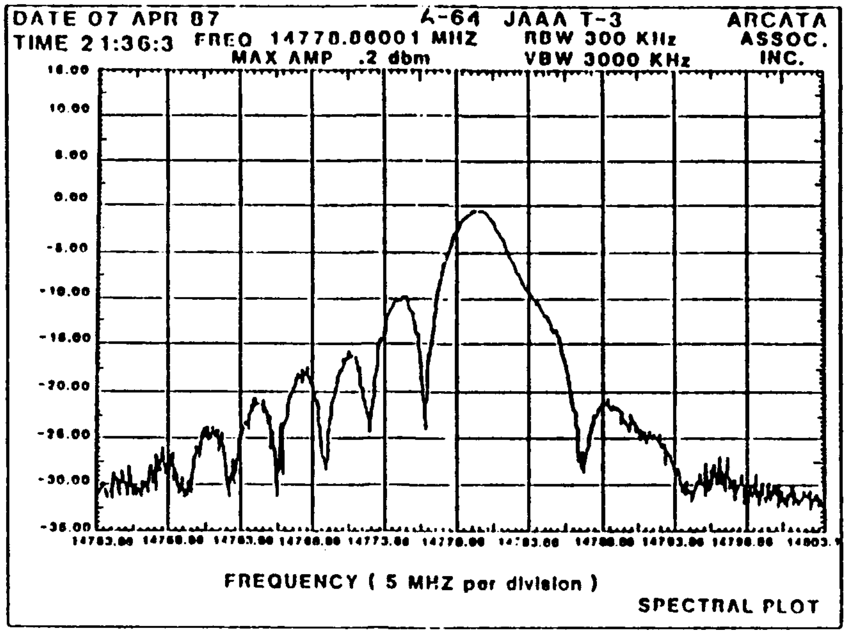
(1) The HP ARS400 operator manually controls the HP receiver system parameters.

(2) The tracker operator manually controls the pointing of directional antennas through the DBA Optical Tracker Joy Stick.

(3) The HP 8566B operator manually controls the receiver system parameters.

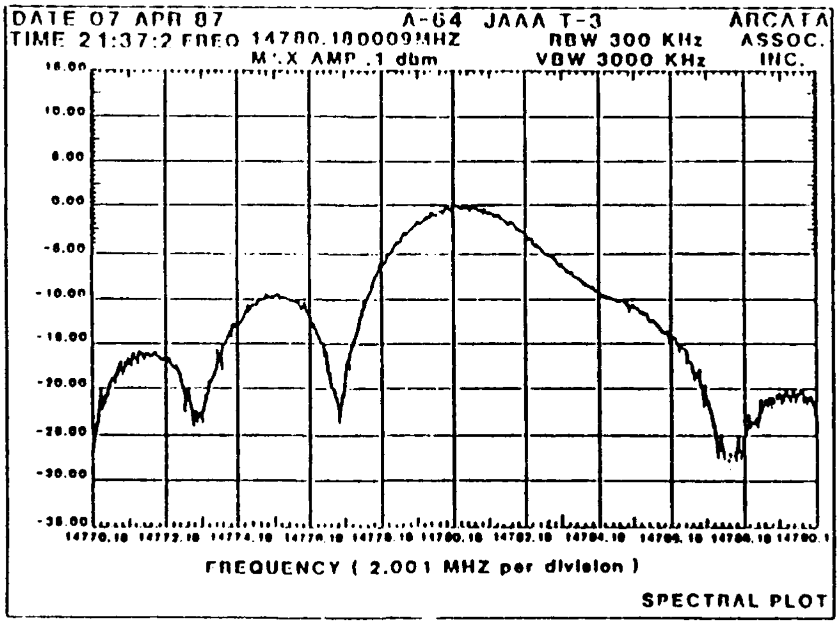


Signal Analysis System (SAS)



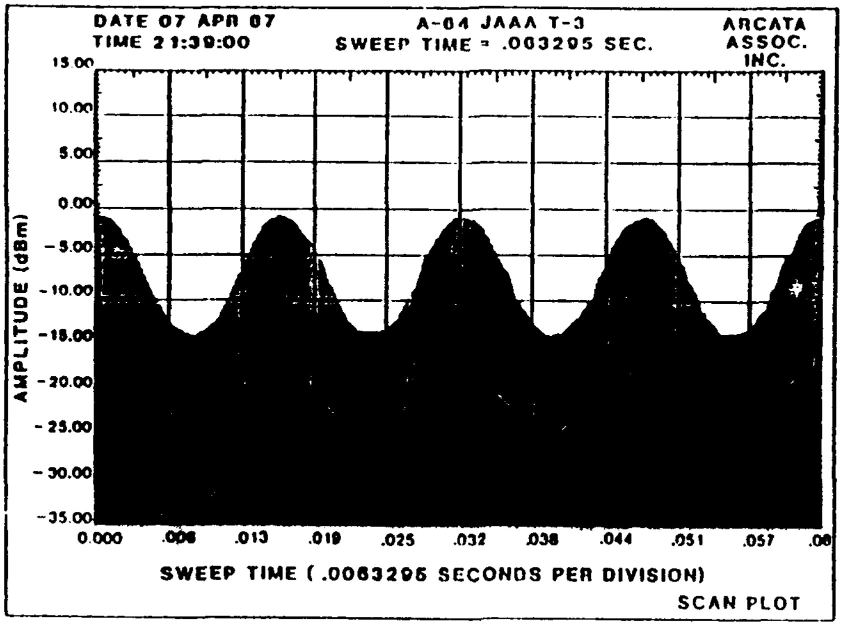
322

Figure B-7. HP 8566B RF Spectral Plot of Signal Amplitude vs Frequency



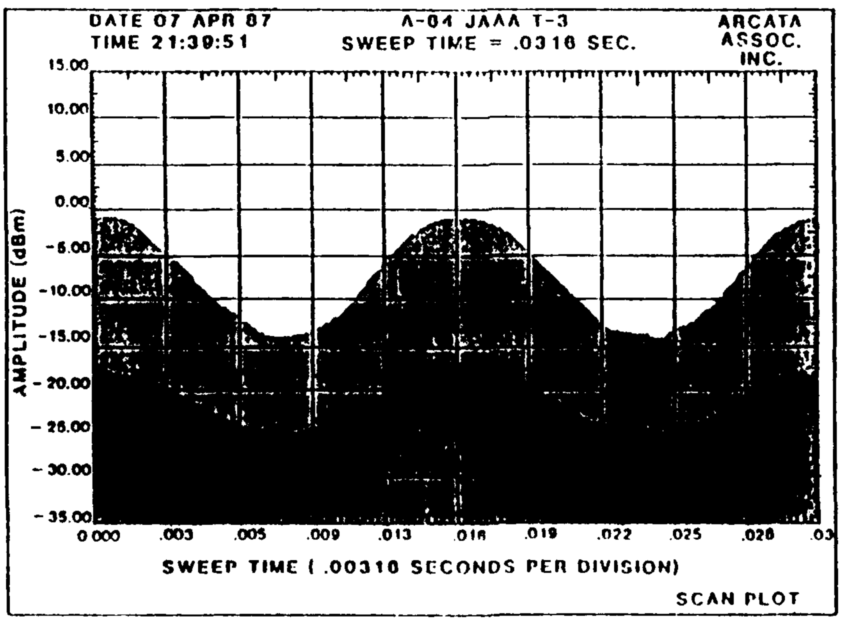
322

Figure B-8. HP 8566B RF Spectral Plot of Signal Amplitude vs Frequency (Expanded)



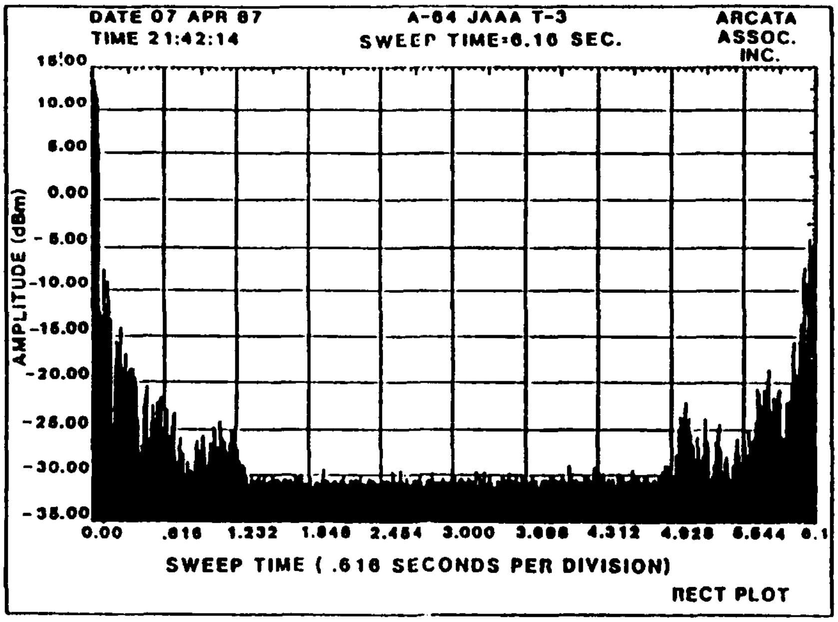
322

Figure B-9. HP 8566B Time Domain Graph of Signal Amplitude vs Time



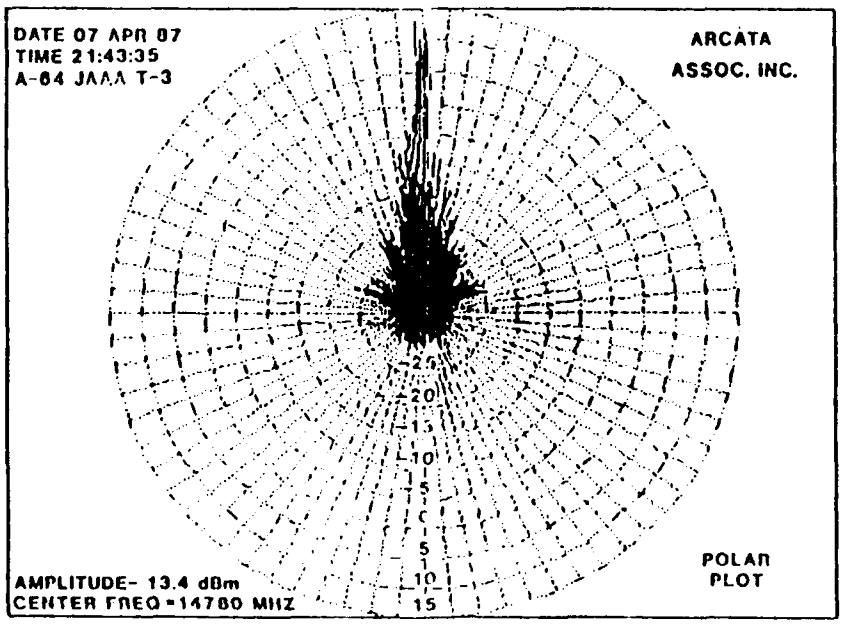
322

Figure B-10. HP 8566B Time Domain Graph of Signal Amplitude vs Time (Expanded)



322

Figure B-11. HP 8566B Rectangular Plot of a Radar System



322

Figure B-12. HP 8566B Polar Plot of a Radar System only during the specific time period that a given airborne ECM system is expected to produce an output pulse. The various discriminatory capabilities permit the AN/MSR-T4 to generate a stream of data samples that can be associated with specific RF sources.

d. Signal Tracking. The ability to keep its directional antennas boresighted on the airborne ECM system is critical to the AN/MSR-T4 mission. Measurements in a receiver subsystem begin only when an incoming signal exceeds a program-controlled qualifying theshold. A misdirected antenna causes the ECM input signal to drop below the required level and interrupts the data being received by the AN/MSR-T4. The targets that must be tracked are high-speed, highly maneuverable aircraft. The EW exercise being monitored by the AN/MSR-T4 will generally be part of a larger-scale exercise, such as a bomb scoring exercise. That exercise may require the aircraft producing the ECM signal to take evasive action. The data required to control antenna tracking cannot be extracted from the signals being processed by the receiver subsystems in the AN/MSR-T4. An external source must provide the tracking data that is needed to keep the AN/MSR-T4 directional antennas on target. The range tracking radar can provide the necessary data when the AN/MSR-T4 is deployed on a range that has tracking facilities. The AN/MSQ-117 IFF tracker system can provide the necessary tracking data whenever the AN/MSR-T4 does not have range tracking facilities available. Except when collocated with RF power sources, the antenna pointing information is the only input, other than primary power, required for AN/MSR-T4 operation. The RF blanker pretriggers are required whenever the AN/MSR-T4 is collocated with RF power sources.

e. Signal Measurement. The values of threshold-qualified signals, are measured automatically by standard measuring instruments. The quantitative data produced by these instruments permits firmware-driven decision logic to determine such values as:

- RF center frequency
- Frequency agility range and period
- Interpulse period (pulse repetition interval)
- Pulse repetition stagger range and rate
- Pulse width
- Antenna scan rates (rotational, raster, or conical)
- Antenna polarization
- Antenna mainlobe width
- Effective radiated power (erp)
- Spectral power density

Measurement of these signals for the threat emitter input signal permits the threat to be categorized; measurement of these parameters for the ECM system response permits evaluation of noise, pulse, and continuous wave (CW) countermeasures.

3-2. SYSTEM OVERVIEW.

a. Functions. The AN/MSR-T4 consists of functionally oriented subsystems that are generally either computer-based or microprocessor-based. Figure 3-2 shows these subsystems and the general data flow that occurs. Each subsystem has a specific set of functions to perform within the system. Generally, the subsystem contains the microprocessor or the computer that directs the step-by-step operations required to perform these functions. The operating instructions that program these step-by-step operations are stored as firmware (in the microprocessor-based subsystems) or as software (in the computer-based subsystems). Each subsystem is capable of semiautonomous operation. A given subsystem needs only to be assigned a particular set of tasks by Control Processor A7A1 and be provided with the initialization data related to these tasks. Task assignment and initialization can be performed at any time prior to actual need. When triggered by the occurrence of a firmware-specified event (such as a signal exceeding a preset threshold), a subsystem can then perform its assigned task without requiring intervention from the Control Processor. Measurement operations within a subsystem can be synchronized by the signal being measured; there is no time lost in signaling between the subsystem and the Control Processor. As a result, a given subsystem can adapt itself automatically to randomly occurring asynchronous events (relative to the timing within the AN/MSR-T4 subsystem). Also, data collection can be initiated by the occurrence of an event (such as a signal falling below a preset threshold or a frequency scan reaching a preset limit). Parameter measurements being initiated automatically by the occurrence of an event and data collection by termination of the event means the data is available for analysis in near real time. All the subsystems are conducting independent, simultaneous operations under supervision of the Control Processor, allowing Signal Analysis Processor A6A5 to receive (in near real time) the data it needs to perform ECM evaluation, threat evaluation, and spectrum management support tasks.

b. **Antennas.** The antennas provide continuous frequency coverage from 0.03 to 18 GHz. Theat emitter activity and voice communication are monitored through omnidirectional antennas. Satellite timing is monitored through a geostationary orbiting earth satellite (GOES). RF emissions from airborne sources are monitored through directional antennas. The directional antennas accept input signals of vertical and horizontal polarization. Antenna movement is required so the system can track the selected aircraft supplying RF input. Additionally, the gain of the directional antennas compensates for the lower-level signals received from more distant sources. The directional/polarization capability also enables measurement of some parameters related to the source antenna. Antenna outputs connect to the Antenna Switching and Signal Conditioning Matrix (ASASCM). TV Camera A24A7, Interphone A4A6, TV Camera Control A4A4, and TV Monitor A4A3 complete the antenna subsystem.

c. **Antenna Switching and Signal Preconditioning.** ASASCM Directional/Omni Remote Unit A24A4, ASASCM Master Control Chassis A2A1, and RF Blanker Distribution Matrix A3A4 perform this function. The ASASCM amplifies input signals to preserve overall system sensitivity. The ASASCM also controls switching of any receiver (except communications and satellite time receivers) to any antenna. The RF blanker receives pretrigger information and sends the ASASCM the blanking pulses used to prevent interference with data collection. The ASASCM outputs connect to the multiple receiver subsystem.

d. **Performance Verification.** This function calibrates and monitors the performance of the system elements whose operation is critical to the reception and analysis of an incoming RF signal. Equipment failures detected during performance verification are displayed by the Control Processor, supporting the system's maintenance and calibration requirements.

e. **Multiple Receivers.** The receivers consist of Communications Receiver A2A9, audio and range timing components, wideband (wb) receiver, and two narrowband (nb) receivers. The wb receiver consists of RF to IF Downconverter A1A2, Acousto Optic Processor A1A12, and Acousto Optic Processor Data Interface Unit A1A7. The wb receiver monitors spectrum activity. The data it produces can be used by the Control Processor to direct the nb receivers to the frequency of an input signal. Each nb receiver consists of a Spectrum Analyzer (A1A3, A2A2), IF Signal Demodulator (A1A6, A2A5), and Receiver Processor (A1A5, A2A4). The nb receivers collect data on pulse-type signals (pulse width, pulse amplitude, and interpulse period). Additionally, data needed to analyze a complex

AN/MSR-T4

SYSTEM DESCRIPTION

PURPOSE - AUTOMATICALLY RECEIVE, ANALYZE, DISPLAY, AND RECORD CHARACTERISTICS OF THREAT SIGNALS, ECM WAVEFORMS AND OTHER RF ACTIVITY IN NEAR REAL TIME.

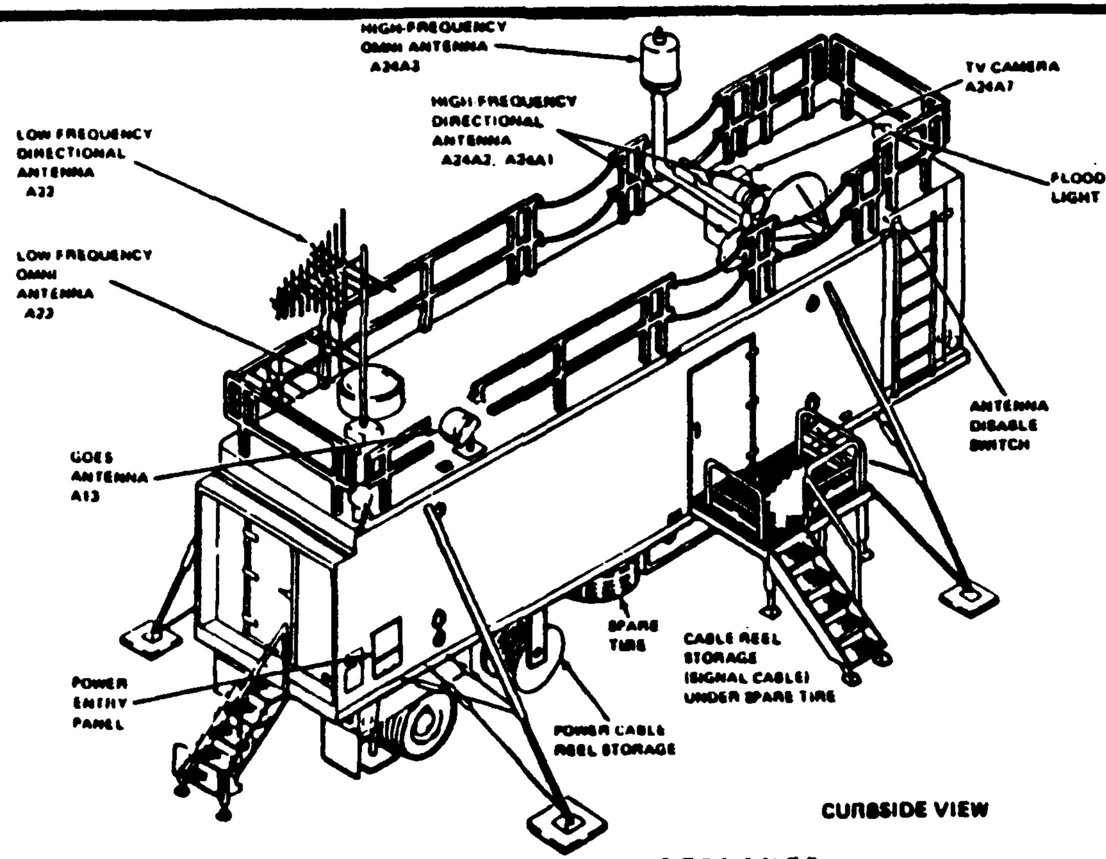
FREQUENCY COVERAGE - 30 MHZ TO 18 GHZ (GROWTH TO 40 GHZ)

OPERATIONAL CAPABILITIES -

- THREAT VALIDATION/CALIBRATION
- ECM ANALYSIS
- SPECTRUM SURVEILLANCE/SUPPORT
- COMMUNICATIONS RECORDING

AN/MSR-T4

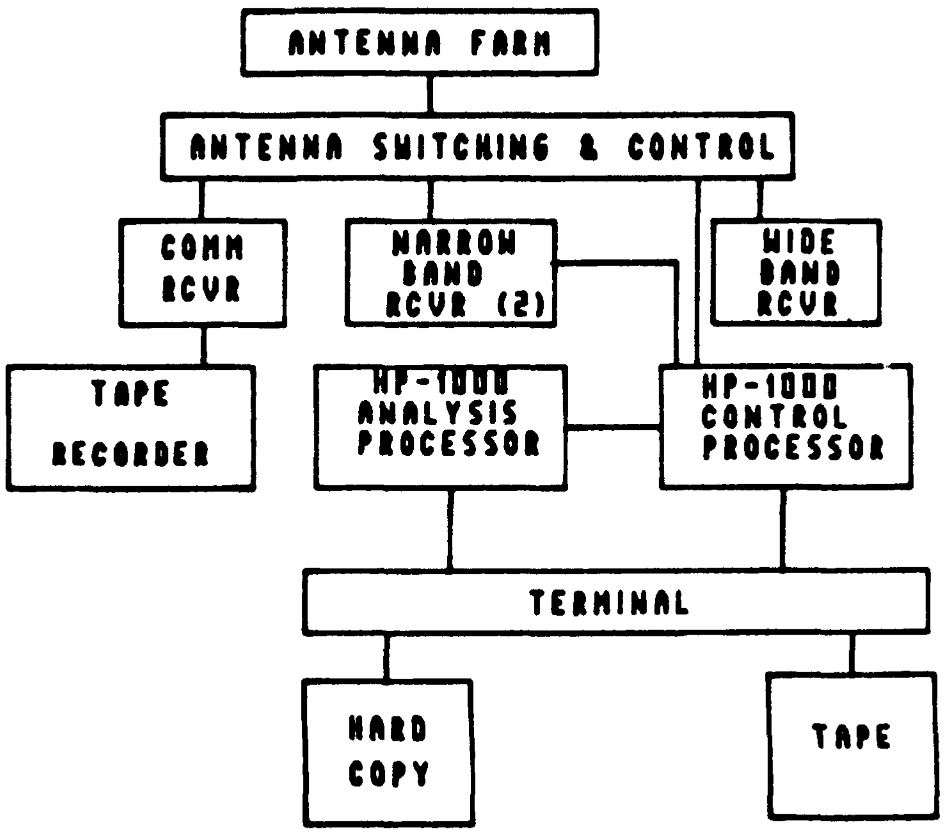
SYSTEM DESCRIPTION

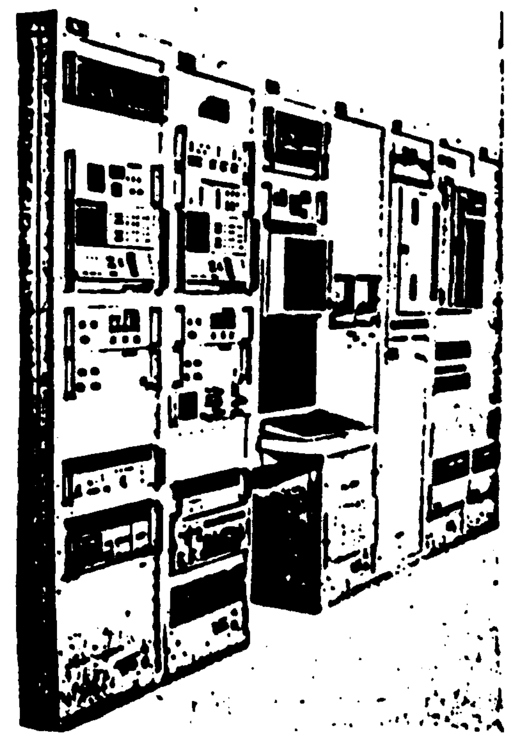


AN/MSR-T4 FULLY DEPLOYED

AN/MSR-T4

SYSTEM DESCRIPTION





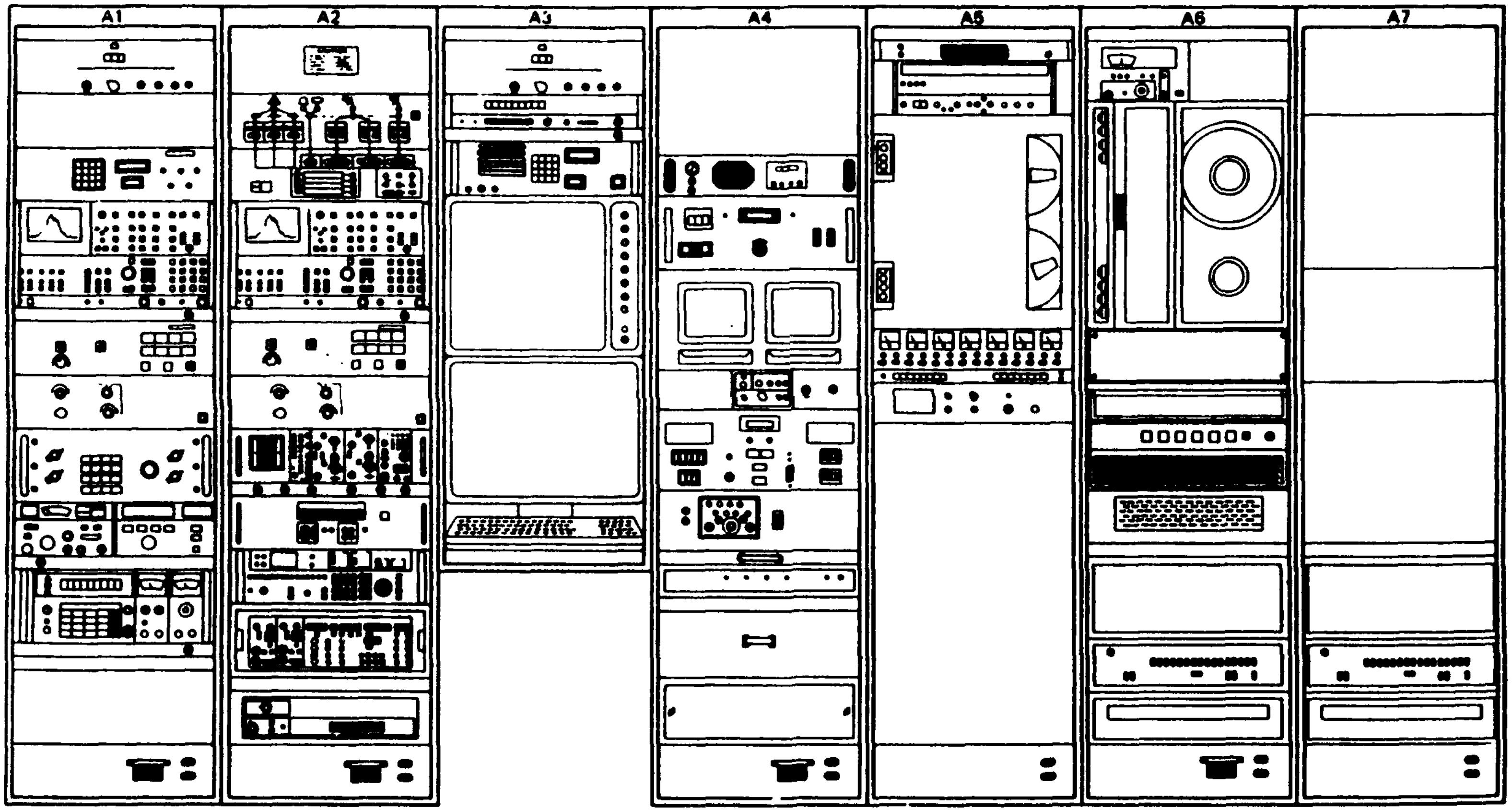


Figure 1-2. AN/MSR-T4 Van Equipments

3.2.1.1.3 Intermediate Data Output. The AN/MSR-T4 shall provide intermediate data displays during the measurement processes involved with the requirements of 3.2.1.1.1 and 3.2.1.1.2. This intermediate data shall be the raw data and/or selected portions of the raw data which is being accumulated in real time and which will be subsequently analyzed and formatted for the final data output described in 3.2.1.1.4. The intermediate data shall be continuously updated and displayed during collection, temporarily stored on a magnetic disc, and stored permanently on a magnetic tape for post-mission use and future reference. The intermediate data shall consist of, but not be limited to, the following:

a. Target position data
b. Signal frequency domain characteristics
c. Event measurement times
d. Signal time domain characteristics
e. Detected signal modulation characteristics
f. Selected AN/MSR-T4 equipment configuration data

The purpose of displaying the data is to (1) assure the operator that data are being collected during actual operations and (2) provide a basis for corrective action and for operations log comments if unforeseen problems have occurred during operations and are clearly evident in the real time data displays.

3.2.1.1.4 Final Data Output. The required data shall be output in various specific formats as described in Section 10, Appendix I. This data shall be displayed to the operator, hard copied and, as required, transmitted to a designated remote location.

3.2.1.1.5 Spectrum Management Support. The AN/MSR-T4 shall provide an automatic intermittently executed spectrum surveillance routine of designated restricted frequency bands during conduct of ECM test and training exercises. The spectrum surveillance routine output shall indicate the frequency of any emission originating from any equipment on the participating aircraft (excluding radar skin returns) within the restricted frequency bands. The frequency of a detected emission shall be immediately displayed to the AN/MSR-T4 operator so that corrective action can be initiated with the participating aircraft. The data shall be stored for inclusion in the final output results sent to the Bomb Wings (see Section 10). The currently designated restricted bands are shown in Table 4.

3.2.1.2 Performance-TAC. The AN/MSR-T4 shall provide the performance described in 3.2.1.2.1 through 3.2.1.2.6 and Section 10, Appendix I.

3.2.1.2.1 Threat Radar Performance Evaluation. This paragraph is identical to 3.2.1.1.1.

3.2.1.2.2 ECM Performance Evaluation. This paragraph is identical to 3.2.1.1.2.

3.2.1.2.3 Communications Receiving/Recording. The AN/MSR-T4 shall automatically intercept, dwell for variable periods, and record on magnetic tape standard AM/FM communications voice transmissions on designated frequencies in the range below about 500 MHz. The analog voice data will be serially recorded in conjunction with an IRIG-B time code generator. The receiver dwell time will be encoded and multiplexed on the unused binary digital field within the IRIG-B time frame. In addition, a digital output of dwell frequency will be provided at the UCDP.

3.2.1.2.4 Spectrum Management Support. The AN/MSR-T4 shall provide specific data in support of range spectrum management activities. It shall perform this support function during specified periods and at designated locations within the TAC range complex. The data shall consist of measurements which will identify EM emissions of known and unknown origins that are within line-of-sight (at a -5° to + 80° elevation angle) and/or intercept range of the AN/MSR-T4. The parameters/characteristics which shall be measured are the following:

a. Frequency
b. Emission characteristics, i.e., AM, FM, cw, pulsed
c. Azimuth relative to measurement location
d. Threat radar parameters/characteristics listed in 3.7.4.4.2.1.a and Section 10, Appendix I. Those parameters/characteristics listed in 3.7.4.4.2.1.a and Section 10, Appendix I as may be measured, from unknown/unidentified emission sources when intercepted by the AN/MSR-T4, shall be provided.

3.2.1.2.5 Intermediate Data Output. This paragraph is identical to 3.2.1.1.3, except the data shall be optionally output to the UCDP for immediate transmission to a remote location.

3.2.1.2.6 Final Data Output. The final data consists of the stored intermediate data, or an analysis of the stored intermediate data which is output to the UCDP in the format described in Section 10, Appendix I.

3.2.1.2.7 Operational Concept. The AN/MSR-T4 shall provide the performance described in 3.2.1.2.1 through 3.2.1.2.6 during the aircraft engagement scenarios and other operations scenarios described in 3.2.1.2.7.1 through 3.2.1.2.7.3.

3.2.1.2.7.3 Spectrum Management Support Scenarios. A spectrum management support scenario is conducted during periods which will not conflict with the acquisition of data for the testing and training scenarios. The periods may be between aircraft sorties of a particular scenario, or between scenarios. The purpose of a spectrum management support scenario is to (1) verify that range users are operating equipment in accordance with established frequency authorizations and (2) provide data to resolve cases of inadvertent interference either between participants or non-participants in range activities. The AN/MSR-T4 shall perform the following:

a. Provide accurate, reliable measurements of the parameters/characteristics listed in 3.2.1.2.4 when surveying bands of interest designated by a specific scenario.

b. Output the intermediate data or final data to the UCDP in its required format for transmission to its remote location. The final data format is described in Section 10, Appendix I.

c. As required, and within the measurement capabilities necessary to meet the requirements of 3.2.1.2.1 through 3.2.1.2.3, provide special data per 3.2.1.2.4 and 10.3.2.3 which might assist in the resolution of radio frequency interference problems associated with range activites. The available data display and data storage facilities shall be utilized as appropriate.

3.2.1.2.7.4 Ground-based Threat Validation. This paragraph is identical to 3.2.1.1.6.3 except threat signals shall be measured by direct radiation to the sited AN/MSR-T4 as well as from a fixed calibrated target, if available.

3.2.1.2.8 Availability/Utilization. This paragraph is identical to 3.2.1.1.7.

3.2.2 Physical Characteristics. The physical characteristics requirements described in the following paragraphs shall be applicable to all AN/MSR-T4 systems.

3.2.2.1 Configuration

3.2.2.1.1 The configuration of the AN/MSR-T4 shall provide a central control area which shall include one operator console, space for one observer and an IFF target tracking operator console if required. The minimum area shall be 32 square feet with no dimension less than 42 inches. There will also be separate space provided for the AN/MST-T1A remote operator consoles/racks (see 3.3.g) which require two (2) operator positions and one (1) observer position (minimum area shall be 32 square feet).

3.2.2.1.2 Thirty (30) inches of standard 19 inch width rack space shall be provided for mounting a user provided Modular Instrumentation Package (MIP). A power strip with a minimum of six 115/120 VAC, 15 amperes, 60 Hz, single-phase, grounded outlets shall be provided on the equipment rack in the vicinity of the MIP rack space.

3.2.2.3 Deployment. The AN/MSR-T4 shall be capable of being completely set up within 4 hours by 3 men after arriving at its destination. An additional 4 hours will be allowed for equipment warmup, stabilization, alignment and calibration. The AN/MSR-T4 shall be capable of placement at a site with no special preparation to either the system or the site in terms of concrete pads or other similar equipment. Leveling and stability jacks with the necessary hardware to provide a leveling capability and stability to meet the required system performance specifications when the system is operated on a longitudinal inclination of up to 4 percent downhill or 10 percent uphill and a lateral inclination of up to 10 percent from the normal operating position (normal level in all planes) shall be provided. Level devices shall be provided in appropriate locations. This requirement also applies to the optional IFF target tracking van.

3.2.3 Reliability

3.2.3.1 Quantitative Requirements

3.2.3.1.1 Mean Time Between Failures (MTBF). The AN/MSR-T4, including the autonomous IFF target tracking subsystem, shall have a lower test MTBF of 150 hours and an upper test MTBF of 300 hours and the MTBF of the AN/MSR-T4 without the autonomous IFF target tracking subsystems shall not be less than 200 hours under the conditions contained in the approved reliability test plan.

3.2.3.1.2 Mean Time Between Critical Failures (MTBCF). The AN/MSR-T4, including the autonomous IFF target tracking subsystem, shall have a MTBCF of no less than 400 hours.

3.2.4 Maintainability

3.2.4.1 Quantitative Requirements

3.2.4.1.1 Corrective Maintenance Time. The AN/MSR-T4, including the autonomous IFF target tracking subsystem, shall have a mean corrective maintenance time (Mct) of 30 minutes, a maximum corrective maintenance time (Mmax ct) of 90 minutes (95th percentile) when repaired by two Air Force Maintenance technicians of skill level 5 or equivalent.

3.2.4.1.2 Preventive Maintenance. The AN/MSR-T4, including the autonomous IFF target tracking subsystem, shall have a preventive maintenance period not to exceed 60 minutes (or 2 man-hours). The preventive maintenance period shall occur no more frequently than once for every 168 hours of operation.

3.2.4.1.3 DELETED.

3.2.5 Environmental Conditions. The environmental conditions described in the following paragraphs are applicable to all AN/MSR-T4 systems.

APPENDIX G

PACIFIC MISSILE TEST CENTER

POINT MUGU, CALIFORNIA

PACIFIC MISSILE TEST CENTER

FREQUENCY MANAGEMENT DIVISION

FREQUENCY INTERFERENCE CONTROL CENTER

FREQUENCY MONITORING INSTRUCTIONS

VOLUME I

JULY 1986

WRITTEN BY

A.D. MARTINEZ

HEAD, FREQUENCY CONTROL SECTION

APPROVED BY

E.E. ANGLE

HEAD, FREQUENCY MANAGEMENT DIVISION

PREFACE

These Frequency Monitoring Instructions were written for the purpose of training communication equipment operators and electronic technician operators in the unique procedures required to survey and to monitor the radio frequency spectrum. It provides fundamental information on sources of radio frequency interference and methods on how to use the various positions within the Frequency Monitoring Stations such as telemetry, radar, command, control and communication systems.

TABLE OF CONTENTS

INTRODUCTION

The Frequency Management Division (FMD) is responsible for the procurement, assignment, scheduling, and coordination of all radio frequencies utilized at Point Mugu. Authorizations for the use of frequencies on the range are obtained from the NAVAL ELECTROMAGNETIC SPECTRUM CENTER, WASHINGTON, D.C. Most frequencies employed by missile programs are assigned on a share basis and use must be scheduled to preclude mutual interference.

The task of frequency monitoring involves the extensive use of radio frequency (RF) surveillance and measurement equipment for the purpose of searching and scanning the RF spectrum to identify signals that may interfere with any electronic facility that is supporting range operations. Frequency monitoring performed by FMD can best be broken down into six functions, defined as follows:

1. Spectrum Surveillance: The task of observing the electromagnetic spectrum to determine usage parameters for management, coordination, and interference prevention.

2. Direction Finding: The process of determining true bearing by observing maximum signal strength on a specially designed system consisting of a rotatable antenna of a highly directive nature, a sensitive receiver, and a bearing indicator.

3. Signal Analysis: Determining the characteristics of signals, such as the type of modulation, relative signal strength, and band width.

4. Frequency Measurement: Accurate frequency determination by

the use of frequency meters such as transfer oscillators which are accurate to plus or minus 0.0001 per cent.

5. Deviation Measurement: Measurement of low and high frequencies of a modulated RF carrier.

6. Recording: Recording of command control audio tones.

INTERFERENCE CONTROL

Identification and Location of Signals

Normal transmissions such as amplitude modulation, frequency modulation, continuous wave, teletype, and facsimile, can be identified by call letters, frequency, date, time of transmission and type of emission. The source of these signals can normally be located by directing an inquiry through appropriate channels.

The identification and location of interference signals is usually more complicated. The aural and visual presentations provided by various equipments must be studied carefully, in order to achieve favorable results. Written material on interference, in addition to that presented, is readily available and should be used. Information such as various signals as seen on panoramic adaptors is particularly useful. Identification of most aural signals is associated with narrowband and broadband interference and is provided in the table attached. The following paragraphs contain information relating to identification and location of radiated signals.

Sources of Narrowband Interference

Narrowband interference consists of co-channel, adjacent-channel harmonic and other signals at a distant frequency. Undesirable response appears in a narrow tuning range when these signals are detected. Most signals of this type are listed in the table.

Co-channel and adjacent-channel transmissions consists of authorized or unauthorized transmissions present simultaneously with a desired signal. Conditions causing these signals may be unusual propagation conditions, frequency spectrum crowding, use of excessively high power, lack of proper maintenance procedures or off-frequency operation.

Harmonics can be present in the radiated output of a transmitter employing a class "C" final output stage. This is caused by faulty elimination of the harmonics generated by the non-linear amplification characteristics of class "C" operation.

Intermodulation and cross-modulation signals can be generated if two transmitter signals are mixed in a common non-linear impedance and then transmitted normally. This can occur if electromagnetic energy from one transmitter is coupled to another.

Parasitics are undesirable oscillations generated in a transmitter from combinations of stray inductance and capacity. Other spurious outputs consist of undesirable signals associated with frequency multiplication or modulation present in a transmitter output. In some cases receivers ac. .s a transmitter, radiating energy at their local oscillator frequency or harmonics.

Radar transmitter can cause interference in other radars when operating with excessive or high-level sidebands. Drifting from the assigned frequency in a radar network, or non-synchronized pulse recurrence frequencies between two radar systems, can cause interference.

Sources of Broadband Interference

Broadband interference is principally caused by transients formed when current carrying circuits are opened or closed. It consists of a wide range of frequencies detectable by receivers over a broadband tuning range.

Powerline interfernce is caused by sudden changes in potential due to current surges, corona, arching, or interruption of a power circuit. Fluorescent lights cause interference due to normal gas ionization within the tube, or by defective components. Arc welding interference, generated by the arc and associated equipment. Electric ignition interference is caused by transients in low and high tension ignition circuits. Rotating machinery causes transients due to commutation arching or static discharge. RF interference can emanate from apparatus such as diathermy equipment, X-ray machines, or induction heaters.

Radar modulator pulse is made up of a wide range of harmonics of the basic PRF. These harmonics may be received directly from the radar antenna or from metal portions of the radar equipment. Intermittent connections and static discharges from wires or other metalic objects, may cause transients. Ambient noise interference may be caused by static discharge (thunderstorms), precipitation static, discharge from snow, dust, rain, hail, etc., and cosmic noise.

AUDIBLE INDICATIONS ASSOCIATED WITH INTERFERENCE

TYPE OF AUDIBLE INTERFERENCE	POSSIBLE SOURCE AND MECHANISM
1. whistling and squeals	co-channel; adjacent channel; harmonics; intermediate frequency oscillations; intermodulation
2. 60 or 120 cycle hum	power line noise; fluorescent lights; power supply hum
3. popping	ignition systems; magnetos
4. crackling	regulators; corona discharge; static charges
5. sputtering, loud, continuous	arc welders; high frequency appratus; diathermy, etc; arc lamps
6. co-channel	Occurs when the center frequency or carrier of an undesired signal falls in any portion of the pass band of the receiver.
7. image frequency	Occurs when the image frequency ot a desired signal is strong enough to be not fully attenuated in the resonant receiver circuits used to reject the signal. (The signal mixes with the local oscillator frequency to produce the intermediate frequency, and is passed through).
8. undesired transmission	co-channel; adjacent channel; harmonics; intermodulation; intermediate frequency
9. clicking, regular or irregular	electric calculating machines; code machines; ignition; mercury arc rectifiers; relays; switches; teletypewriters; thermostatic control

10. buzzing	buzzers; vibrators
11. whining	rotating machines, radar modulator pulse
12. frying	electric arcs; continuously arcing contacts
13. adjacent channel	Occurs when some sidebands, but not the center frequency or carrier of an undesired signal falls within the pass band of receiver.
14. harmonic	Occurs when a signal is produced at the receiver intermediate frequency by harmonics (generated in the input circuits of the receiver) of received signals other than the desired signal and/or the local oscillator frequency.
15. intermodulation (communications receivers)	Occurs with simultaneous reception of two or more signals which combine in receiver input circuits to produce the desired frequency to which the receiver is tuned, or in response to a spurious response frequency of the receiver
16. cross modulation	Occurs when the modulation of an undesired signal is impressed upon a desired signal in the receiver input circuits.
17. intermodulation (radar receivers)	Results when a combination of local oscillators frequency and spectral-line frequency produces a signal of sufficient amplitude at the receivers intermediate frequency, or when the separation between spectral-lines is equal to the intermediate frequency of the receiver.

18. shock excitation	Occurs when a short distance pulse signal is applied to a resonant circuit, setting up damped oscillation at the natural resonant frequency of the tuned circuits for a few cycles.

TELEMETERING MONITORING POSITION OPERATING INSTRUCTIONS

Purpose

To protect Range Users from unintentional radio frequency (RF) interference and to ensure that all frequency users are duly authorized and adhere to all restrictions imposed (i.e., tolerance, emission type, bandwidth, etc.).

I. Duties

a. Monitoring of spectrums (1435-1535, and 2200-2300 MHz)

1. Identify signals
2. Measure signals-frequency
3. Log all signals intercepted

b. Inform station supervisor of all pertinent information concerning monitoring position

1. Tolerance violations
2. Unauthorized emissions
3. Interfering signals
4. Non-compliance with instructions

c. Operate with other monitoring sites and mobile facilities as required

II. Equipment

a. Type

1. Microtel MS 904
2. WJ 1234

b. Capabilities

1. Spectrum and signal analysis

2. Frequency measurement

3. Direction finding (DF)

III. Signal Analysis

a. Type

1. FM	4. MCW
2. AM	5. T/M
3. CW	6. Pulse

b. Bandwidth

c. Relative signal strength

IV. Telemetering Position Log

a. Self explanatory

V. Method

a. Check operations schedule for daily telemetering frequency assignments. Ensure that frequency assignments do not conflict. All assignment discrepancies shall be referred to the FREQUENCY INTERFERENCE CONTROL CENTER (FICC) who will take appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Identify all signals intercepted with those frequencies assigned to projects for daily operations. If a signal cannot be identified as an authorized assignment, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations such as San Nicolas Island (SNI).

1. If signal is determine to be a local origin, The FICC will dispatch mobile facility to area of suspicion in order

to locate and identify source of transmission.

2. If signal is determine to be of remote origin, attempt to identify area of origin (i.e., Los Angeles, desert activities, ect.). The FICC will direct the mobile facility to locate and identify the transmission source so that coordination can be effected.

d. Measure all signals intercepted to ensure that local assignments conform to frequency tolerance requirements and that signals of remote origin are sufficiently spaced from local signals so as not to cause interference.

1. If a signal of local origin is measured out of tolerance, notify the FICC who will take corrective action.

2. If a signal of remote origin is measured within 250 KHz of a local assignment authorized for a scheduled operation, notify the FICC of possible interference source. Provide complete information concerning signal characteristics and enter time of notificaiation in log. The FICC will be notified of any signal, regardless of frequency separation if interference appears likely.

3. When periodic measurements of a local assignment shows abnormal transmitter operation, such as, excessive frequency drift, spurious emission, low relative signal strength, etc., a separate log shall be maintained with discrepancy details in order that a conclusive report may be made to project concerned so that corrective action can be taken.

e. The monitoring station telemetering position operation will take all action concerning telemetry interference and will fill out an interference report with all required information concerning the complaint. He will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference, giving full details and request assistance. He will further keep the FICC fully informed of investigation progress so that a conclusive report can be made to the Branch Head.

1. If the interfering signal appears to be a local origin, the FICC will dispatch the mobile facility to the area of suspicion obtained by use of direction finding techniques, in order to locate and identify source of transmission. When offender is identified, notify the FICC/Branch Head who will take appropriate action.

2. If interfering signal is determined to be of remote origin, the FICC will notify the Branch Head.

RADIO COMMAND CONTROL MONITORING POSITION OPERATING INSTRUCTIONS

Purpose

To protect Range projects from unintentional radio frequency (RF) interference and to ensure that all frequency users are duly authorized and adhere to all restrictions imposed (i.e., tolerance, emission type, bandwidth, etc.).

I. Duties

a. Monitoring of spectrum (406-455 MHz)

1. Identification of signals

(a) All signals used on operations

(b) All signals apparent

2. Analysis of signals

(a) Measurement

(1) FM-3

(2) FM-6

(3) Transfer oscillator

(b) Signal strength

(c) Signal characteristics

(1) AM

(2) FM

(3) Pulse

(4) CW

(5) MCW

b. Keep the FICC informed of all pertinent information concerning position.

1. Tolerance violations

2. Unauthorized emissions

3. Interfering signals

4. Non-compliance with Range instructions

c. Operational checks

1. Checkouts with projects equipment

(a) Pen recorders

d. Recordings

1. Make chart recordings of all air/surface launches

(a) For verification of interference

II. <u>Equipment Used</u>

a. FRW-3

b. Decoders as required

c. SLR

d. Recorders

1. Brush

2. Esterline Angus

III. <u>Method</u>

a. Check operations schedule and teletype for daily Command Control frequency assignments. Ensure that frequency assignments do not conflict. All assignment discrepancies shall be referred to the FICC who will take appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Identify all signals intercepted with those frequencies assigned to project for daily operations. If a signal cannot be identified as an authorized assignment, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations.

1. If signal is determine to be of local origin, the FICC will dispatch mobile facility to area of suspicion obtained by use of direction finding techniques in order to locate and identify source of transmission. When offender is identified, and signal source is one which has not been authorized, a radio discipline violation report will be issued.

2. If signal is determined to be of remote origin, attempt to identify area of origin (i.e., Los Angeles, desert activities, etc). The FICC will direct the mobile facility to locate and identify the transmission source so that coordination can be effected.

d. Ensure that local assignments conform to frequency tolerance requirements and that signals of remote origin are sufficiently spaced from local signals so as not to cause interference.

1. If a signal of local origin is measured out of tolerance, notify the FICC who will take corrective action.

2. If a signal of remote origin is measured within 1.0 MHz of a local assignment authorized for a schedule operation, notify the FICC of possible interference source. Provide him with complete information concerning signal characteristics and enter in log time of notification. Responsible person will be notified of any signal, regardless of frequency separation if interference appears likely.

3. When periodic measurements of a local assignment shows abnormal transmitter operation, such as excessive frequency

drift, spurious emission, low relative signal strength, ect., notify the FICC.

e. The monitoring station Command Control position operator will take all actions concerning Command Control interference and will fill out an interference report with all required information concerning the complaint. He will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference, giving full details and requesting assistance. He will further keep the FICC fully informed of the investigation progress so that a conclusive report can be made to the Branch Head.

1. If the interfering signal appears to be of local origin, the FICC will dispatch the mobile facility to area of suspicion, obtained by use of direction finding techniques, in order to locate and identify source of transmission. When offender is identified, notify the FICC/Branch Head who will take appropriate action.

2. If interfering signal is determined to be of remote origin, the FICC will notify The Branch Head.

RADIO COMMAND CONTROL RECORDING POSITION OPERATING INSTRUCTIONS

Purpose

To detect extraneous Radio Command Control signals and to ensure that proper operation of control station transmitting equipment.

1. Method

a. The monitoring station recording position operator will coordinate marking of all charts being made at each monitoring station.

b. Marking beginning and ending of chart with: Operation number, date, frequency, operator, and recorder number being used.

c. Monitor assigned communication circuit for status of missile launch or drone take-off.

d. Start recorder prior to missile or drone R/C control checkouts and identify each R/C control function pre-check with contolling station when applicable.

e. Update operational schedule by checking with teletype.

1. If pre-check from a particular station appears abnormal, notify the FICC who will take corrective action before launch.

f. Mark recording with all pertinent data including:

1. Count down, commencing at the minus 2 warning or when drone is spotted.

2. Zero time (missile launch or drone take-off).

3. Transfers of control, showing controlling station.

4. Time of landing or splash, if applicable.

g. Ensure range timing in on.

h. If Command Control controlled missile or drone is being used as a target, include count-down of firing operation, commencing at the minus 2 minute warning.

i. During transfers of control, observe panoramic adaptor to ensure that control signal is of sufficient strength to maintain positive control. If control station is at extended range, request other facility to provide this data.

RADAR MONITORING POSITION OPERATING INSTRUCTIONS

Purpose

In order to protect Range Users from unintentional RF interference and to ensure that radar and beacon frequencies are compatible.

I. Duties

a. Monitoring of spectrum from 90 MHz to 40 GHz

1. Determine radar and beacon requirements

2. Analysis to ensure compatibility

3. Identification of intercepted signals

(a) Triangulation with other facilities

(b) Identification by known bearings, fingerprints, etc.

4. Measurement of local signals

5. Log all signals

b. Assist FICC or endorse silence requirements as necessary

c. Be aware of ECM operations and effect on local operations

d. Handle station interference problems (local) associated with spectrum monitored.

e. Keep the FICC informed of all pertinent data concerning monitoring position.

f. Operate with other frequency monitoring sites and mobile facilities as required

g. Close liaison with other operating positions concerned with same operation.

II. Equipment Use

a. Reception of all RF signals in band covered

1. Band covered

(a) 90 MHz to 40 GHz

2. Types of signals

(a) CW

(b) MCW

(c) Pulse

(d) T/M

(e) FM

b. Frequency measurement

1. Direct

2. Transfer OSC

c. Signal analysis

1. Panoramic presentation

2. Pulse analyzation

(a) SCI-2160

(b) WJ-1921

III. Method

a. Check daily operations schedule to determine operational radar and beacon requirements identified wiht specific aircraft, drone, or missile installations.

1. Analyze radar and beacon frequency configurations to ensure that frequency assignments do not conflict. It is imperative that the beacon interrogation frequency be separated at least 10 MHz from any other signal sources and when possible 15 MHz separation should be maintained. All frequency assignment discrepancies shall

be referred to the FICC for appropriate action.

b. Log all signals intercepted and enter required data on standard log sheet.

c. Identify all signals intercepted with Range radar and beacon assignments being utilized for daily operations. If a signal can not be indentified with Range assignments, determine whether it is of local or remote origin by coordinating direction finding results with the other monitoring stations.

1. If signal is determined to be of local origin, the FICC will dispatch the mobile facility to area of suspicion in order to locate and identify source of transmission.

2. If signal is determined to be of remote origin attempt to identify area of origin. The FICC will request assistance from the Western Area Frequency Coordinator (WAFC).

d. Measure all signals intercepted to ensure that local radars conform to authorized frequency assignments and that signals of remote origin are sufficiently spaced form local assignments so as not to cause interference. This is particularly important in the case of the beacon interrogation frequencies.

1. If a radar frequency appears to have been changed without prior coordination, notify the FICC who will take appropriate action.

2. If a signal of remote origin is measured within 10 MHz of a beacon interrogation frequency being utilized for a scheduled operation, notify the FICC of possible interferring source. Provide him with complete information concerning signal

characteristics and enter time of notification in log. The FICC should be notified of any signal, regardless of frequency separation if interference appears likely.

3. When daily periodic measurements of a local assignment show abnormal transmitter operation, such as: Excessive frequency drift, spurious emissions, low relative signal strength, etc., notify the FICC.

e. The frequency monitoring station radar position operator will take all action concerning radar interference and will fill out an interference report with all required information concerning the complaint. He will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference, giving full details and request assistance. He will further keep the FICC fully informed of investigation progress so that a conclusive report an be made to the Branch Head.

1. If the interfering signal appears to be a local origin, the FICC will dispatch the mobile facility to area of suspicion obtained by use of direction finding techniques, in order to locate and identify source of transmission. When offender is identified, notify the FICC who will take appropriate action.

2. If interfering signal is determined to be a remote origin, the FICC will request assistance from the WAFC.

f. When radar silence is in effect for a scheduled operation, ensure that prescribed frequency band is clear. All discrepancies will be referred to the FICC for corrective action.

g. All ECM operations, either of local of remote origin, will be monitored to ensure that harmful interference is not encountered on frequencies utilized restricted bands.

MISCELLANEOUS MONITORING POSITION OPERATING INSTRUCTIONS

Purpose

To protect Range Users from unintentional RF interfernce and to ensure that users are duly authorized and adhere to all restrictions imposed.

I. Duties

a. Monitoring of communications circuits

1. Make spot checks of all daily assigned circuits

(a) Measure frequency of users

(b) Check call sign of users

(c) Check for interference

(d) Check for circuit procedure

(e) Check for non-compliance of CNO instruction

b. Monitoring of permanently assigned radio relay links, propagation study transmitters and aids to navigation

1. Measure frequency

2. Check bandwidth

3. Check relative signal strength

4. Monitor for interference

c. Keep the FICC informed of all pertinent information concerning position.

II. Method

a. Measure all signals to ensure that assignments conform to frequency tolerance requiements and that signals of remote origin are sufficiently spaced from local signals so as not to cause interference.

1. If a local assignment is measured out of tolerance, notify the FICC who will take corrective action.

2. If a signal of remote origin is measured close enough to a local assignment which could possibly cause interference, attempt to identify area of origin. When available, notify the FICC.

3. When periodic measurements of local assignment shows abnormal transmitter operation such as excessive frequency drift, spurious emissions, low relative signal strength, etc., a good log shall be maintained with discrepancy details in order that conclusive report may be made to the project concerned so that corrective action can be taken.

b. The monitoring station miscellaneous position operator will take all actions concerning interference to those frequencies and will fill out a report with all required information concerning the complaint. He will immediately monitor the frequency involved and notify the other monitoring stations of the reported interference giving full details and request assistance. He will further keep the FICC fully informed of investigation progress so that a conclusive report can be made to the Branch Head.

HF MONITORING SYSTEMS

1. Equipment Used

   a. WJ-8718

   b. Suitable long-wire or dipole antenna

   c. panadaptor

2. Purpose

   a. General purpose monitoring of AM, SSB, CW, or FM signals in the 100 KHz to 30 KHz

   b. Frequency measurement

3. System Description

The HF receiver system, with appropriate antenna, may be used for monitoring any AM, FM, SSB, or CW signal in its tuning range. The receiver audio output may be monitored with headphones or loudspeaker. The panadapter provides a visual presentation of the signal to which the receiver is tuned as well as of signals adjacent to the center signal.

For specific operating instructions for each piece of equipment read operators manual.

MOBILE MONITORING POSITION OPERATING INSTRUCTIONS

1. Duties

a. Interference

1. Proceed to area of suspicion as directed by the FICC

2. Monitor assigned frequency for interfering signal using appropriate direction finding equipment

3. "Home" in on interfering signal

4. Record source of interference

(a) Activity

(b) Respnsible person (extension)

(c) Time

5. Keep the FICC informed of all developments durning the investigation so that a conclusive report can be made to the Brand Head

b. Monitoring by special request

1. At the request of projects

(a) Such as a check to see if a close-loop TM circuit is radiating

2. At the request of FICC

(a) Remote monitoring as per special operational requirments

COMMAND CONTROL MONITORING SYSTEM (USING NEMS-CLARKE RECEIVING EQUIPMENT)

1. Equipment Used

a. Nems-Clarke 1501A/1502 radio receiver; 55-260 MHz.

b. Nems-Clarke REU-300 range extention unit (frequency converter); 250-900 MHz

c. KY-172A/URW audio decoder, with NMC-built power supply

d. Esterline-Angus model AW, 20-pen graphic recorder

e. Brush 6-pen electric recorder

f. Antenna: suitable omni-directional or high-gain steerable antenna covering the frequency range of 405-550 MHz - selected at antenna patchbay.

g. Antenna control panel for use with steerable antenna, if used

2. Purpose

To receiver, decode, and record command control signals transmitted to drone aircraft of missiles.

3. System Description/Method

The incoming command control signal is fed to the input of the REU-300 range extension unit (frequency converter), which is tuned to the circuit frequency of the command signal. The REU-300 converts this carrier frequency from the 405-550 MHz range down to 60 MHz. The 60 MHz signal is coupled to the input of the 1501A/1502 radio receiver. Command control signals are frequency modulated with control tones in existing command control equipment 20 separate tone channels are employed, either singly or in combination.

The composite audio signal output of the 1501A/1502 receiver is coupled to the input of the KY-172A audio decoder. Control tones are separated by band-pass filters and operate the 20 separate relays in the decoder. The relay contacts are wired to operate the pen motors of the 6/20-pen function recorder to produce a permanent ink-on-paper record of command signals transmitted. The composite audio output of the 1501A/1502 receiver may be connected to the input of a tape recorder if it is desired to tape-record the control tones directly rather than to make a pen recording.

Frequency of incoming carrier signals may be determined by use of the frequency measuring system described elsewhere. AGC voltage of the Nems-Clarke receiver may be recorded by an Esterline-Angus 0-1 milliampere recorder and separate DC amplifier if a record of relative signal strength is desired.

If a high-gain steerable antenna is employed, the operator will have to position his antenna by use of the antenna control equipment mounted adjacent to the receiving position.

NOTE: This equipment is to take the place of AN/FRW-3 command control monitoring equipment, which is presently unavailable. The Nems-Clarke system will require much more care in operating and a considerably higher degree of operator skill than the AN/FRW-3 in order to obtain satisfactory results.

The Nems-Clarke receivers were not designed to handle signals with as high a carrier deviation as is sometimes used on command control circuits. A minor modification has been made in the output circuits of the 1501 receiver to improve its response to command control signals and to provide proper coupling to the following decoder; however, receiver tuning adjustments will be increasingly critical as carrier deviation goes above 250 KHz.

Make deviation readings when requested by projects.

COMMAND CONTROL MONITORING SYSTEM (USING AN/FRW-3 RADIO EQUIPMENT)

1. Equipment Used

a. One set of AN/FRW-3 radio receiving equipment, consisting of:

(1) R-729/FRW-3 radio receiver

(2) KY-172A/URW audio decoder

(3) PP-1401/FRW-3 power supply

b. End equipment as required by nature of operation

c. Antenna, 405-550 MHz, as required by the nature of the operation

2. Purpose

To receive, decode and record command control signals transmitted to drones and missiles.

3. System Description/Method

Incoming carrier signal from the RF patchbay and antenna system is fed to the input of the R-729 receiver. The composite audio output of the receiver, containing the command control tones, is fed to the input of the KY-172A audio decoder. The audio decoder relays (20 tone channel) operate a model AW 20-pen recorder, or other end equipment.

The receiver-decoder combination can be used to operate any of the end equipment described in connection with the Nems-Clarke command monitoring systems.

The ID-18/U monitor panel contains circuitry and two panel-mounted meters to indicate: (1) relative signal strength of the incoming signal by indicating first limiter grid voltage level; and (2) output level of command control tones - audio output of the receiver in volts RMS. On any one particular frequency the first limiter grid volt meter may be calibrated in terms of actual microvolts input to the receiver and, where antenna characteristics and line losses are accurately known, quantitative values of field strength may be determined. At any one fixed setting of receiver audio output controls, the audio level may be calibrated in terms of deviation of the transmitted carrier.

The receiver first limiter grid voltage may also be used to operate a 0-1 milliampere recorder, by way of a separate DC amplifier, for a permanent record of relative signal strength.

NOTE: The AN/FRW-3 is a crystal-controlled receiver (406-549 MHz, in 1-megacycle steps), designed specifically for monitoring command control signals such as transmitted by AN/FRW-2 equipment.

GENERAL PURPOSE VHF/UHF MONITORING SYSTEM

1. Equipment Used

a. Nems-Clarke 1501A (or 1502A) radio receiver; 55-260 MHz.

b. Nems-Clarke REU-300 range extension unit; 250-900 MHz.

c. Nems-Clarke SDU-200-2 spectrum display unit.

d. Antennas: Any three omni-directional or steerable antennas covering all or portions of the frquency range of 55-900 MHz.

2. Purpose

General surveillance, frequency measurement, and recording of AM, FM, or CW radio signals in the frequency range of 55-900 MHz.

3. System Description/Method

Any three antennas, covering appropriate frequency ranges, may be patched to the inputs of the REU-300 range extension unit (frequency converter) at one time. A panel switch on the REU-300 selects the frequency range to be covered and selects the appropriate antenna. In the "DIRECT" position of the range switch the low frequency antenna is connected directly through to the 1501 radio receiver and the receiver may then be tuned throughout its range, 55 to 260 MHz. In the "250-475" position of the range switch the appropriate antenna is connected to the right-hand frequency converter section of the REU-300 and the converter is tuned through its frequency range of 475 to 900 MHz. In the two higher frequency range positions the fixed-frequency output (60 MHz) of the range extension unit is fed to the input of the 1501 radio receiver; the receiver must be set at 60 MHz, while all tuning is done with the range extension unit.

The SDU-200-2 spectrum display unit (panadaptor) is connected to the IF output of the 1501 receiver (21.4 MHz) to provide a visual display of signals adjacent to the frequency to which the receiving system is tuned.

Incoming signal frequencies may be measured using the frequency measuring system described on another page. The audio output of the 1501 receiver may be monitored aurally, fed to a remote point by wire line, or recorded by the Esterline-Angus 0-1 milliampere pen recorder, via a separate DC amplifier, to obtain a record of relative signal strength.

APPENDIX H

WESTERN SPACE AND MISSILE CENTER

VANDENBERG AIR FORCE BASE, CALIFORNIA

WESTERN SPACE & MISSILE CENTER

FREQUENCY MANAGEMENT HANDBOOK

This handbook describes the FCA operational capabilities of the WSMC Frequency Management and is current as of 1 August 1987.

Copies and extracts from this document may not be made without written permission of the Western Space and Missile Center.

Prepared under Contract F04703-86-C-0618.

This handbook is in effect on the date of approval and will supersede all previous Frequency Management Handbooks.

Reviewed by:

2-1-87
L. FLINKINGSHELT Date
Deputy Director
Data Transfer Support Systems
FEDERAL ELECTRIC CORPORATION

Submitted by:

1/2/87
E. J. HAGIN Date
Director
WSMC Division
FEDERAL ELECTRIC CORPORATION

GEORGE A. STETZ, Colonel, USAF
Commander
Western Test Range

8 July 87
Date

FOREWORD

This handbook has been prepared for the Western Space and Missile Center (WSMC) under Contract F04703-86-C-0618.

This handbook is intended for general use and guidance. It will also be useful as an aid in indoctrination and for general reference. The handbook will be updated periodically to record changes in capabilities.

This handbook addresses only the operational aspects of radio frequency management at WSMC; administrative and staff/management guidance and directives are contained in WSMC Regulation 100-7.

Any questions regarding this document should be directed to the Frequency Management Office (SFDS) of the Western Test Range, Systems Support Directorate, Vandenberg AFB, CA 93437 (805) 866-6695 or AV 276-6695.

ABSTRACT

This handbook concisely describes the functions and capabilities of the individual elements of the Frequency Control and Analysis System at Vandenberg Air Force Base and presents a view of their relationship to government and non-government agencies. Additionally, appropriate photographs and diagrams have been included to provide the reader with an "at-a-glance" recognition of the various equipment systems.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

INTRODUCTION

Operational support for the Range Frequency Manager is provided by the Frequency Control & Analysis (FCA) System which is operated, maintained, and managed by the Center Technical Support Contractor (CTSC). The functional elements of the FCA System are:

- o Frequency Control & Analysis Center (FCAC)
- o Frequency Monitoring Station (FMS)
- o Radio Frequency Measurements Laboratory (RFML)
- o FCA mobile and instrumented vans
- o Frequency Management Support Section (FMSS)

Figure 1-1
FCA Facility - Within Building 7011, NVAFB

Subsequent sections of this handbook will describe in detail the individual elements of the FCA System.

SECTION 2

FREQUENCY CONTROL AND ANALYSIS CENTER

2.1 GENERAL

The Frequency Control and Analysis Center (FCAC) (see Figure 2-1) is the operational coordination facility for the Range Frequency Control and Analysis (FCA) System (see Figure 2-2). Additionally, the FCAC functions as a single point of contact for all other elements and range users on operational frequency control matters. The FCAC is manned on a 24 hour/7 day per week basis.

Figure 2-1. FCAC, Interior View

2.2 FUNCTIONS

The FCAC has the operational responsibility to maintain an interference-free radio frequency environment for the Western Test Range. The FCAC provides the functions as described in the following paragraphs in support of the Range Frequency Manager.

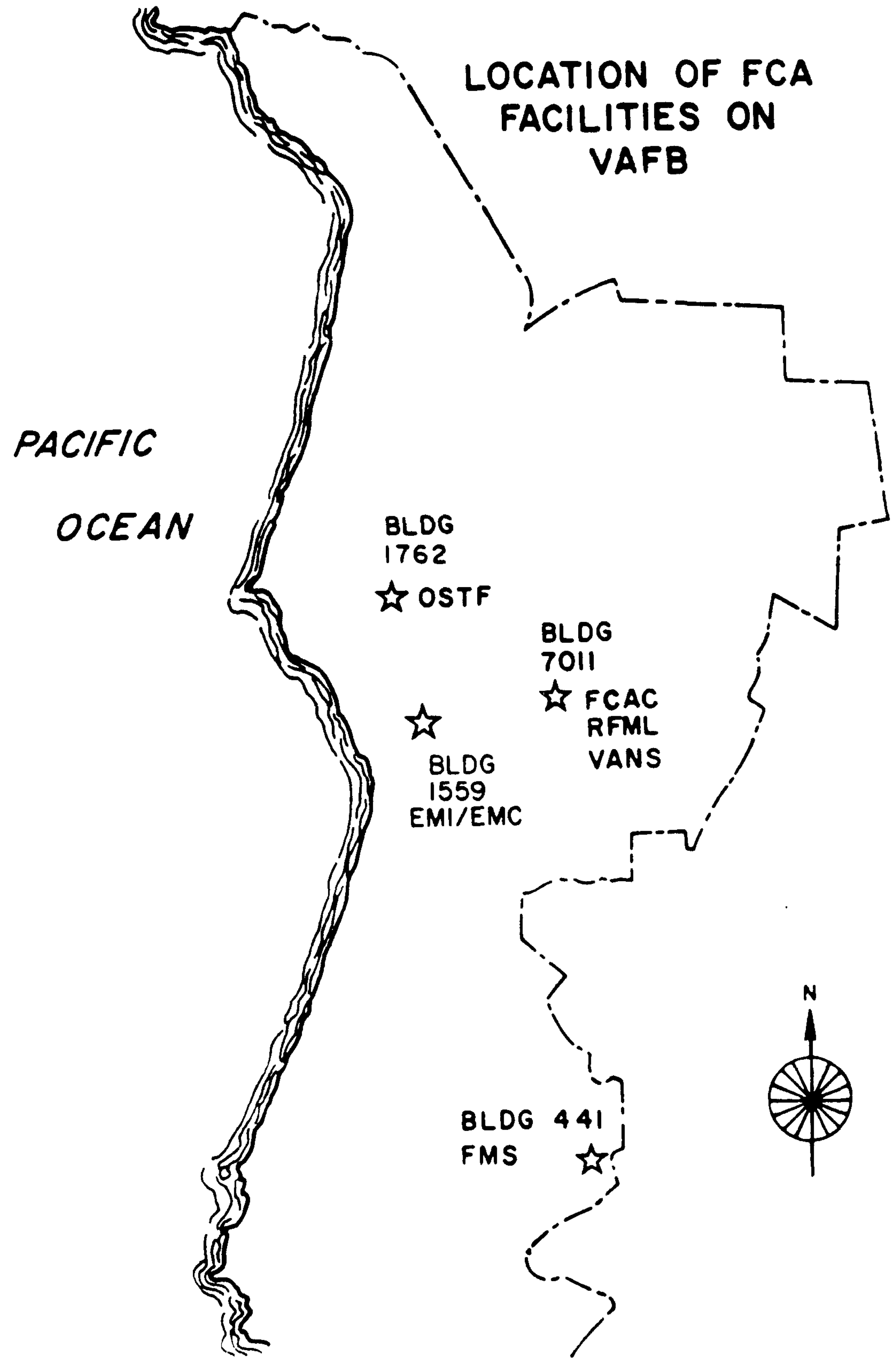


FIGURE 2-2. FCA FACILITIES, VAFB

2.2.1 FREQUENCY SCHEDULING

Radio frequency radiations, 10 kHz and greater, open or closed loop, must be officially scheduled with WSMC Range Scheduling in advance of the requirement. Range Scheduling coordinates these requirements with the Frequency Control and Analysis Center (FCAC) to confirm frequency compatibility and to determine any restrictions which may be necessary to preclude conflicts with other users. Confirmation of scheduled time along with radiation restrictions, if any, will then be passed to the range user by WSMC Range Scheduling. (See Figure 2-3.)

Immediately prior to activating any transmitter on the day of the scheduled test, the range user must contact Range Scheduling to confirm the current radio frequency (RF) compatibility of the test with the FCAC. The Range Scheduling controller will obtain the name and telephone number of cognizant personnel controlling the operation and pass this information to the FCAC. In the event realtime adjustments become necessary, the FCAC will contact the named individual responsible for the test to resolve the problem.

Radiations for scheduled range tests are automatically authorized when the test is posted on the official range schedule. Operation Directives (OD's) authorize specific frequencies in the "Summary of Radio Frequency Utilization" for each range test. Radiation clearance times are those specified in the official countdown for each test. Changes to these clearance times on frequencies must be requested from Range Scheduling (if prior to a test) or from the Range Control Officer (RCO) if during a test.

Authorization to radiate for routine maintenance or adjustment must be obtained from Range Scheduling in advance of the requirement.

Radiation requests which may prove controversial or for which no authorized frequency exists are coordinated by the FCAC with the Range Frequency Manager.

2.2.2 FREQUENCY MEASUREMENTS

Frequency measurements are those (center frequency, bandwidth, etc.) necessary to determine the exact operating frequencies or parameters of electromagnetic equipment. Any range or range user agency may obtain frequency measurements by calling the FCAC who directs the applicable monitoring facility to perform the measurement. Records of actions taken are logged and the results are telephoned to the requesting agency by the FCAC.

2.2.3 FREQUENCY INTERFERENCE REPORTING

In the event of radio frequency interference to scheduled range tests, the FCAC should be notified immediately at (805) 866-9247/3246 or AV276-9247/3246. The FCAC then takes action to locate and eliminate the interference with the assistance of the various range FCA monitoring systems under its control. If the interfering source cannot be controlled by the FCAC, the Range Frequency Manager will be notified.

FCA FREQUENCY SCHEDULING SUPPORT

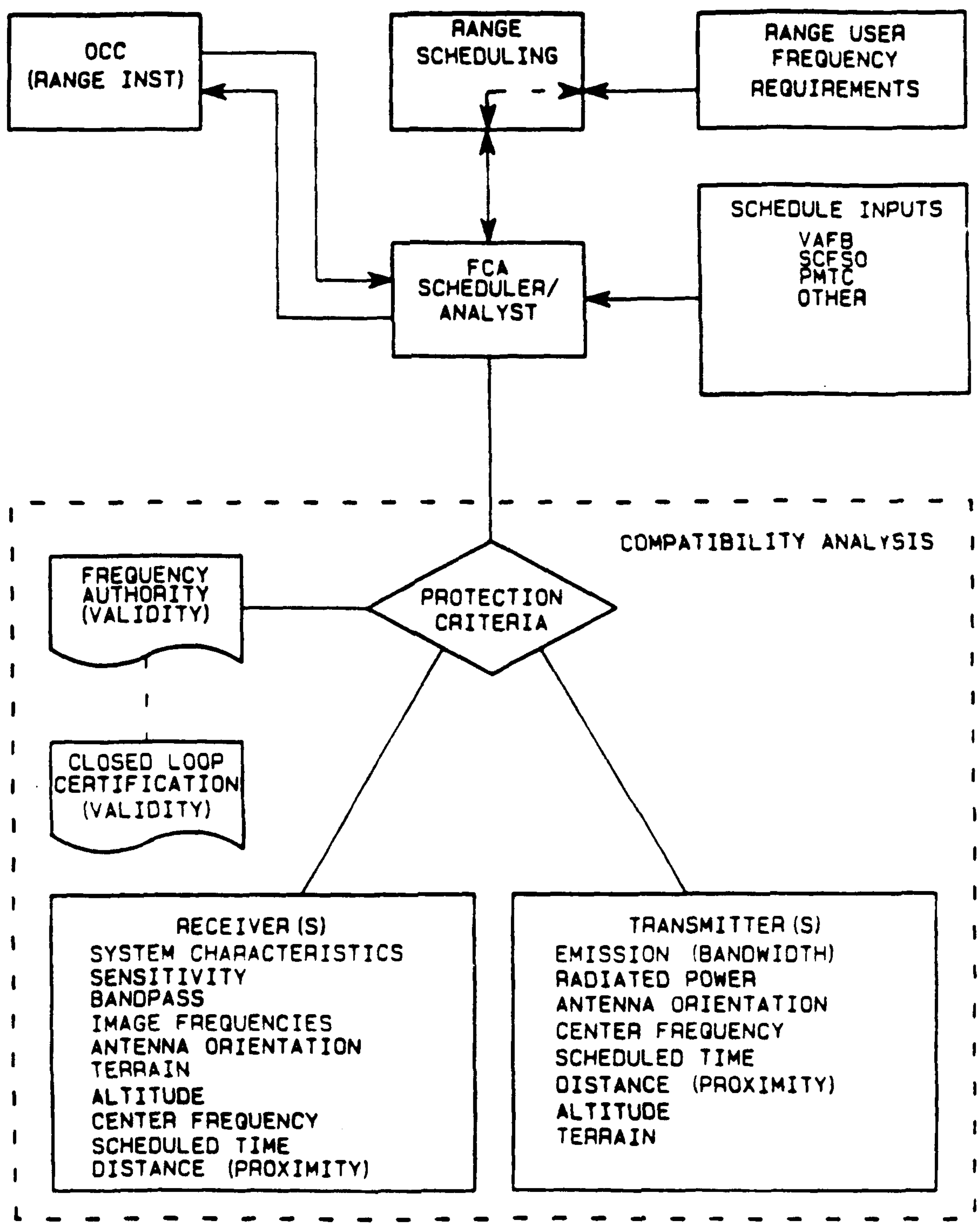


FIGURE 2-3. FCA FREQUENCY SCHEDULING SUPPORT

(2.2.3 cont'd)

Radio frequency interference suspected to be caused by unfriendly sources is to be reported by the Range Control Officer (RCO) to the Range Frequency Manager. Suspected interference of this type is then handled in accordance with current classified directives.

The authority to determine the proper use of a frequency is the responsibility of the Range Frequency Manager. Range frequency users should not directly dispute any outside agency's authority to use a frequency in the event of a conflict. Agencies not radiating in accordance with assigned AFSC Form 5590 parameters as defined in WSMC Radio Frequency Authorization documents and/or the WSMCR 100-7 are notified on AFSC Form 5596, "Radio Frequency Discrepancy Report."

2.2.4 FREQUENCY MONITORING

The FCA coordinates and controls the monitoring of all frequencies listed in Operations Directives including image frequencies of the applicable instrumentation equipment. In addition to controlling the Range fixed and mobile monitoring facilities, the FCA coordinates with associated ranges and agencies as indicated in Figure 2-3. Data collected from Range facilities, range users, and other agencies is correlated, evaluated, and reported to the RCO at specified periods during each test or as requested by the RCO.

2.2.5 RECORDS AND OPERATIONAL DOCUMENTATION

Operational documentation of the following types is available at the FCAC to assist in providing the required support.

- Operations Directives
- Weekly, Daily, and Real-Time Range Schedules
- Satellite Situation Reports and Tracking Schedules
- Frequency Environmental Listings
- Preoperational Briefing Sheets
- Vehicle Peculiar Supplements
- Special Test Instructions

Records of actions taken, data furnished, and requests for service are maintained for historical and analysis purposes. The items retained and times of retention are listed below:

- FCAC Operations Logs (6 months)
- FCAC Radio Logs (6 months)
- FCAC Radio Logs reflecting emergency or distress traffic (12 months)

(2.2.5 cont'd)

- o FCAC Daily Summary of Frequency Scheduling (6 months)
- o FCAC Daily Scheduling Logs (6 months)
- o FCAC Record of Daily Schedule of Operation (6 months)
- o FCAC copy of AFSC Form 5582 "Radio Frequency Interference Report" (12 months)
- o FCAC copy of AFSC Form 5596 "Radio Frequency Discrepancy Report" (12 months)

2.3 COMMUNICATIONS

The FCAC assists the Range Network Control Centers (RNCC's) by furnishing current high frequency propagation prediction data and frequency assignment criteria for use in compiling communications plans.

Within the FCAC there are three operating positions:

- o Frequency Controller #1
- o Frequency Controller #2
- o Scheduling Position Operator

The Frequency Controller #1 and #2 positions have identical communications consoles (see Figure 2-4) which are in full multiple with each other. This allows rapid and efficient communication via direct lines, switched circuits, and radio circuits to locations and personnel involved in frequency usage or control. These locations consist of, but are not limited to, the following:

- o Range Control Officer
- o Range Scheduling
- o Operations Control Supervisor
- o Operations Controllers
- o Network Control Centers
- o Range Instrumentation Sites
- o FCA Monitoring Facilities
- o Range users
- o External Agencies
- o Mobile Facilities

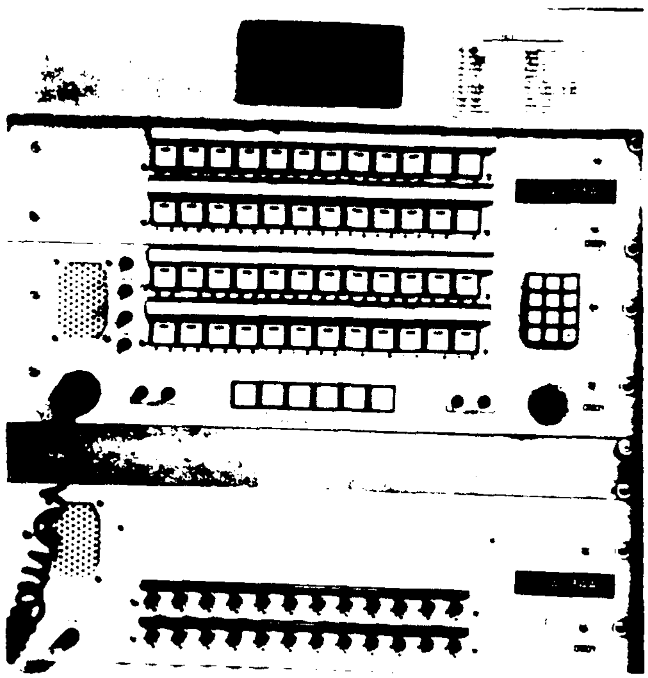


Figure 2-4. Communications Console

The Scheduling Position Operator is responsible for handling not only the frequency coordination of Range scheduled operations, but also Vandenberg Tracking Station Satellite tracking activities. This function is provided in support of future operations and during real-time. Voice communications are provided to locations such as:

- o Range Scheduling
- o Vandenberg Tracking Station (VTS)
- o Other WTR locations as required
- o Other Southern California Test Ranges

As range/range user radio frequency demands have become more complex and critical over the years, the requirements for machine assistance to the FCA frequency analysis, scheduling, and frequency management activities have become increasingly apparent. In June 1978, the Frequency Control & Analysis Center was provided a video data terminal (Datapoint Model 8200) interfacing with the Operations Information System (OIS) at VAFB Range Scheduling. Present OIS programs allow FCA access to the following scheduling information:

- o Outdated operation list
- o Site selection schedule
- o Conflict analysis output

(2.3 cont'd)

- o Daily operations schedule
- o Daily site schedule summary
- o Associated operations by major operation number
- o Operations by operation number output
- o Random operation file output
- o Resource file output
- o Task file detail output
- o Instrumentation status report output
- o Operation detail output
- o Major opertions numbers - task file
- o Operation number lookup - unknown prefix/series
- o Radio frequency spectrum schedule
- o Resource schedule board

Other available program material is available, and files listed above may be increased or deleted as individual user requirements change.

In addition to the OIS system terminal, the FCAC has the capability to store and recover historical radio frequency interference files, radio frequency discrepancy files, V.T.S. satellite tracking data, WTR launch historical information, as well as storage and recovery of miscellaneous FCA files, reports and frequency management data. The XEROX 860 and OMRON/SYKES systems located in Building 7011 provide this extra dimension of machine assistance to assure a rapid and accurate response to WSMC task assignments.

Two HP-86B Computers, complete with ancillary equipment are available to improve the accuracy and efficiency of the frequency scheduling/analysis effort. A remote printer is located at the FMS facility, and at Bldg. 1559, for rapid "hard copy" printout of daily and realtime frequency schedules as sent by the FCAC.

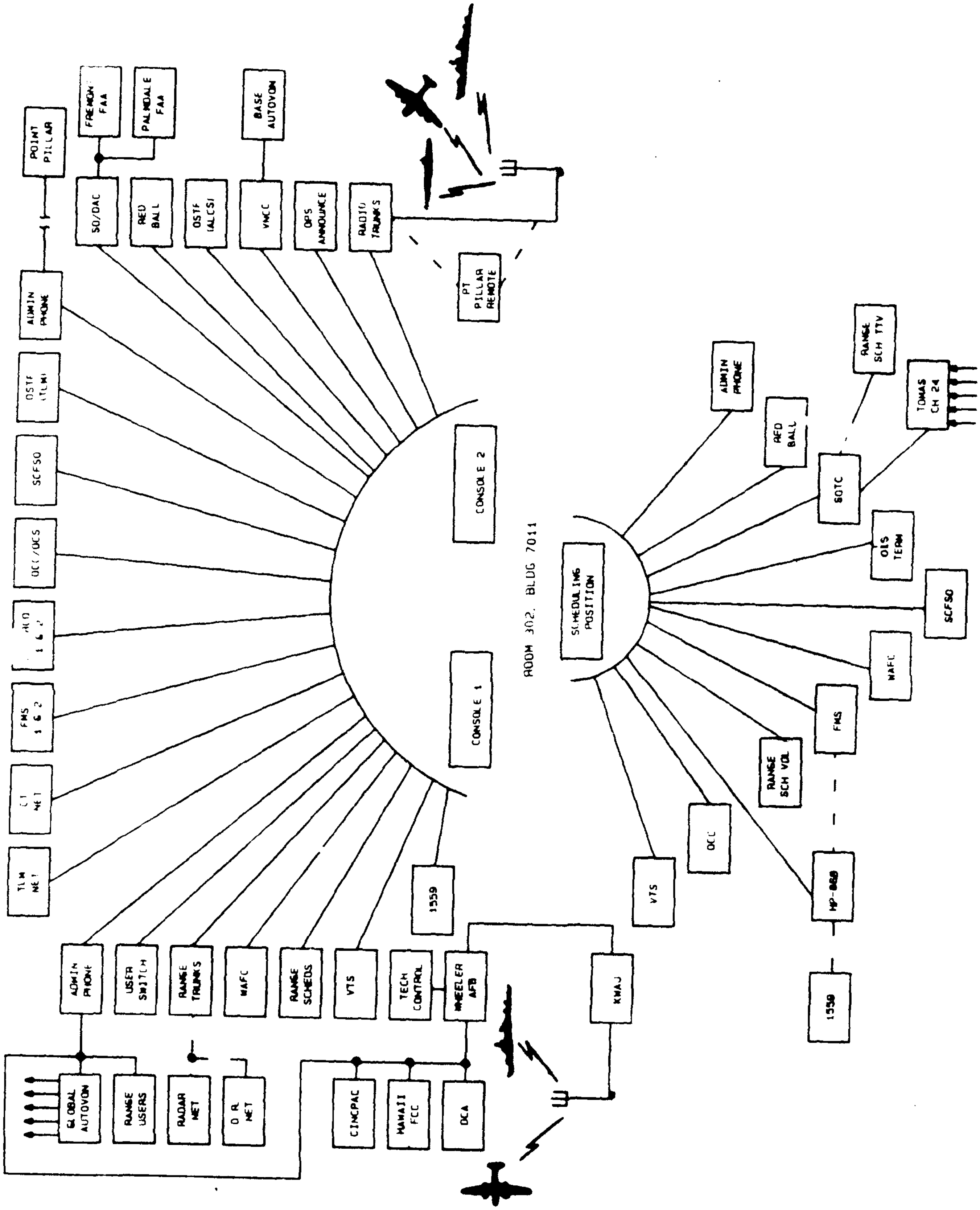


FIGURE 2-6 FCA CENTER COMMUNICATIONS NETWORK

SECTION 3

FREQUENCY MONITORING STATION (FMS)

3.1 GENERAL

The Frequency Monitoring Station, designated FMS, includes two permanent buildings with ancillary antenna installations and is strategically located on SVAFB at 1500 feet elevation north of Honda Ridge to observe VAFB launch sites and support facilities. The station is manned 24 hours a day, 7 days a week. Figure 3-1 shows an exterior view of the facility.

Figure 3-1. Frequency Monitoring Station (FMS)

3.2 FUNCTIONS

The FMS, as one element of the FCA system, receives task assignments in daily activities by coordination through the FCA Center.

Assigned spectrum surveillance, frequency monitoring, protection, and a variety of other support items are provided by FMS in accordance with Range directed tasks, daily scheduled operations, and range user requests. Additionally, the FMS is manned 24 hours a day, 7 days a week to provide frequency monitoring, protection, and RFI investigation for the Vandenberg Tracking Station (VTS) satellite tracking activities.

(3.2 cont'd)

Specific functions include, but are not limited to, the following:

- Frequency monitoring to provide an electromagnetic interference-free radio frequency spectrum
- Verification of authorized radio frequency radiations
- Detection and identification of unknown radio frequency radiations, and reported interference problems
- Spectrum analysis, direction finding, and analysis of radio/microwave frequency signals
- Measurement of center frequency and bandwidth
- Real-time chart and command receiver AGC recordings of command control functions
- Verbal verification and tone frequency readouts of command control functions
- Command control deviation and tone balance measurements
- Delay measurements of CT Site antenna switching, transmitter failover and Site switching
- Deviation measurements of frequency modulation (FM) signals
- Audio (magnetic) tape recordings of known and unknown signals as required
- Detection and assistance in identification of spurious and harmonic signals
- Spectrum photography.

3.3 SYSTEMS SUMMARY

The major equipment systems used at FMS to accomplish the above mentioned functions are briefly described in the following subparagraphs.

3.3.1 RADAR SURVEILLANCE SYSTEM

The Micro-Tel Model MSR 903 Microwave Receiver is a compact surveillance unit with an overall frequency range of 1 to 18 GHz. Electronic tuning is provided in three modes: Full octave band scanning at variable sweep rates, adjustable width scanning with manually tuned center frequency, and unswept manual tuning. A four digit neon display indicates relative center frequency in all modes. Outputs are provided to feed ancillary equipment for accomplishment of center frequency measurements and signal analysis. The system uses a series of narrowband omnidirectional antennas for acquisition and high speed broadband directional antenna to obtain the bearing of received signals. See Figure 3-2.

NOTE: THE INTERIM 12-18 GHz INTERFACE SHOWN IS PENDING FUTURE AMPLIFIER INSTALLATION AND APPLICATION

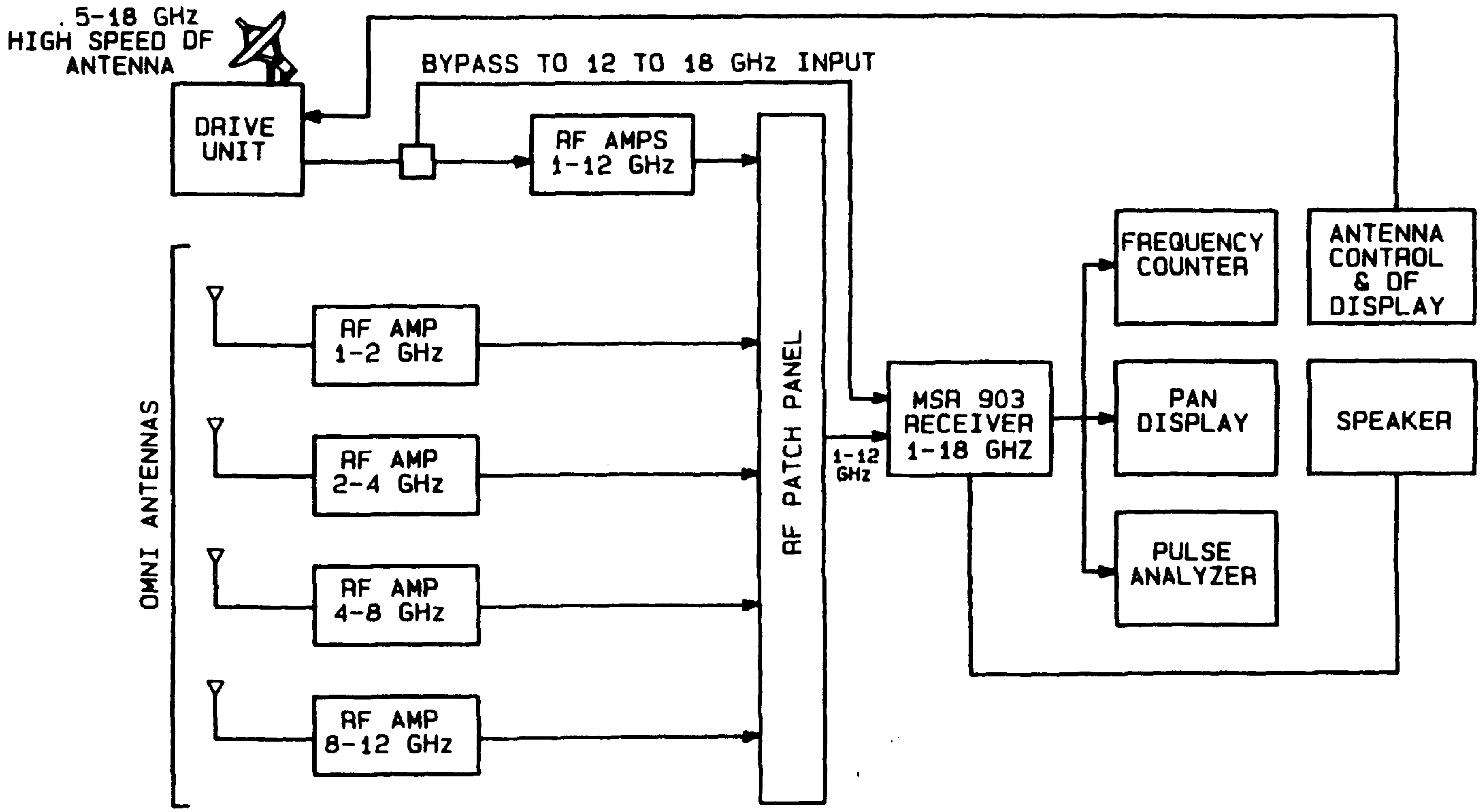


FIGURE 3-2 1 GHz TO 18 GHz RADAR SURVEILLANCE SYSTEM, BLOCK DIAGRAM

3.3.2 20 MHz to 18 GHz SURVEILLANCE SYSTEM

The 20 MHz to 18 GHz Surveillance System provides spectrum surveillance/protection, center frequency, and apparent bandwidth measurements of telemetry signals, backup radar surveillance, and spectrum evaluation including photography and direction finding.

The system includes three WJ565 Receivers using plug-in tuners coupled to a DRO311 frequency counter capable of 20 MHz to 1 GHz coverage, two SR-209 Receivers with plug-in tuners covering 1-2 GHz and 2-4 GHz for primary support of Telemetry Bands, and one MSR-904A Microwave Receiver with signal displays and frequency counter synthesizer covering the 0.03-18 GHz range to supplement Telemetry and Radar support. An SCP 2160 Pulse Analyzer and a HP-141T/HP8555A Spectrum Analyzer/EMTEL 7200B 3 Axis Display combination are included for signal analysis. A Model 8445B Automatic Tracking Preselector covering 1.8 to 18 GHz range is used with the spectrum analyzer to reduce or eliminate signal intermodualtion, in addition to multiple or spurious responses.

The 3-axis display, of special interest, provides a fully calibrated, operator-interactive, animated, real-time 3-axis presentation of electrical signals derived from an input device (HP-141T/8555A Spectrum Analyzer or MSR 903 Receiver) based upon repetitive scanning process. Typical applications are observation of signal analysis and examination of other time or frequency varying signal structures.

Direction finding is accomplished using the following antennas: 90 MHz - 1 GHz Log Periodic, 215 - 265 MHz Quad Helical, 0.3 - 3 GHz Dish, a 1 -12 GHz Dish and a 1 - 18 GHz High Speed DF System. A variety of omnidirectional antennas are available for coverage of 20 MHz to 12 GHz frequency spectrum.

A secondary position includes one SCR7220 Auto Sweep 0.02-1 GHz Receiver/Display, one AN/GLR-9 Receiving Set, covering 30 MHz - 4 GHz, a 0.3 -3 GHz DF antenna including preamplifiers, and omni-directional antennas without preamplifiers in the 30 MHz - 4 GHz frequency range supplementing the primary system. Figure 3-3 displays the block diagram for the primary monitoring position.

3.3.3 COMMAND TRANSMITTERS MONITORING AND RECORDING SYSTEM

This dual system, as shown in Figure 3-4, is designed to cover the frequency range of 250 MHz to 500 MHz; however, this range can be expanded from 30 MHz to 4 GHz as the RF tuners of the AN/GLR-9 used in the 300 MHz to 4 GHz surveillance system are directly interchangeable with the Model SR-209 VHF/UHF Receiver used in this system.

The system provides capability for surveillance and recording of signals in the Missile Flight Termination Control band. Data recorded includes command functions, relative signal strength and FM deviation, Lift-off, and IRIG timing as received at the FMS. The data are recorded on heat-sensitive Z-fold 8 channel chart paper allowing convenient access to any part of the recorded data during the recording process.

3.3.4 ICRS TEST STATION

The ICRS (Improved Command Receiver System) Test Station at FMS is used for recording analog traces of command transmitter monitoring system

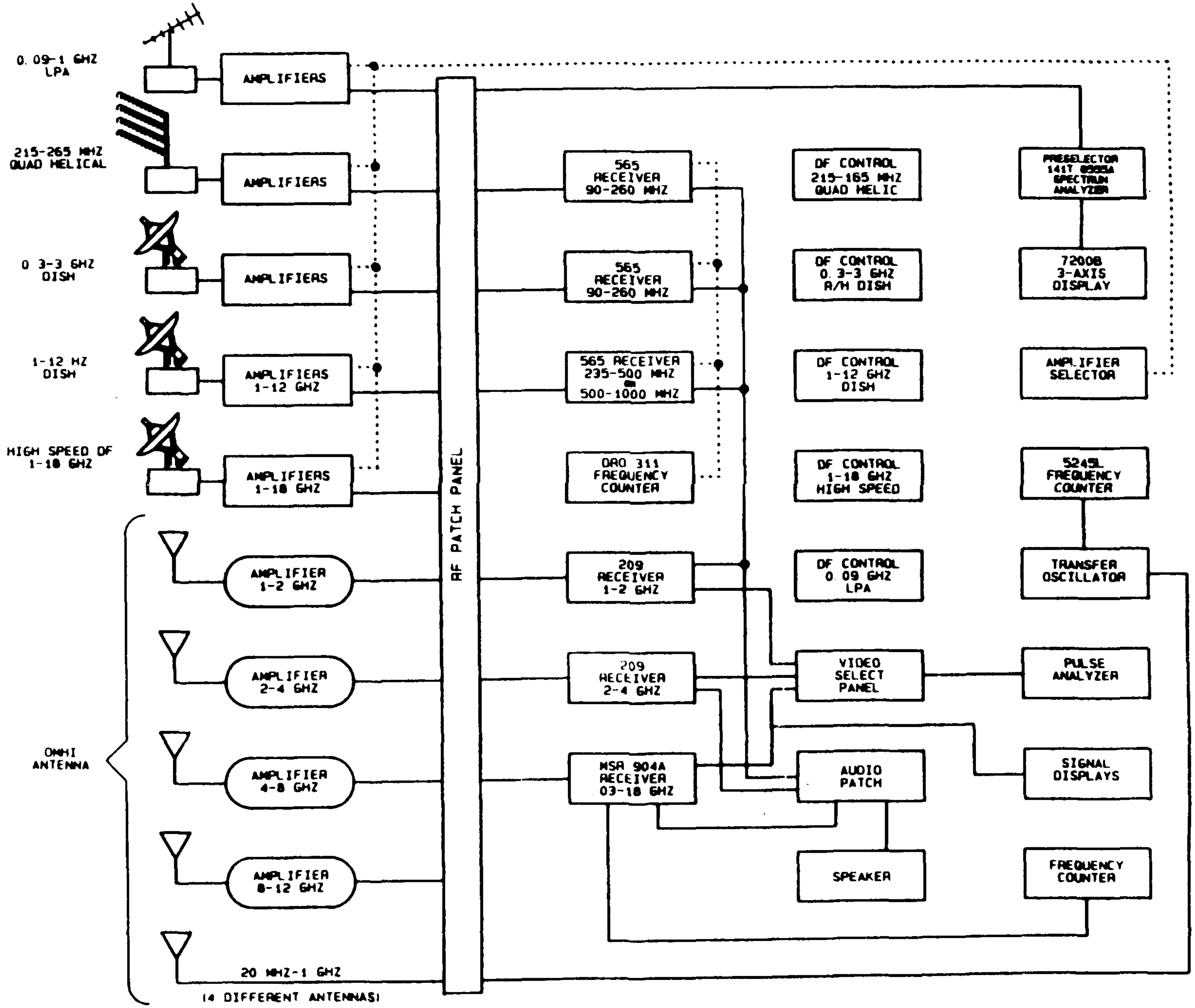


FIGURE 3-3. 20 MHZ TO 18 GHZ SURVEILLANCE SYSTEM

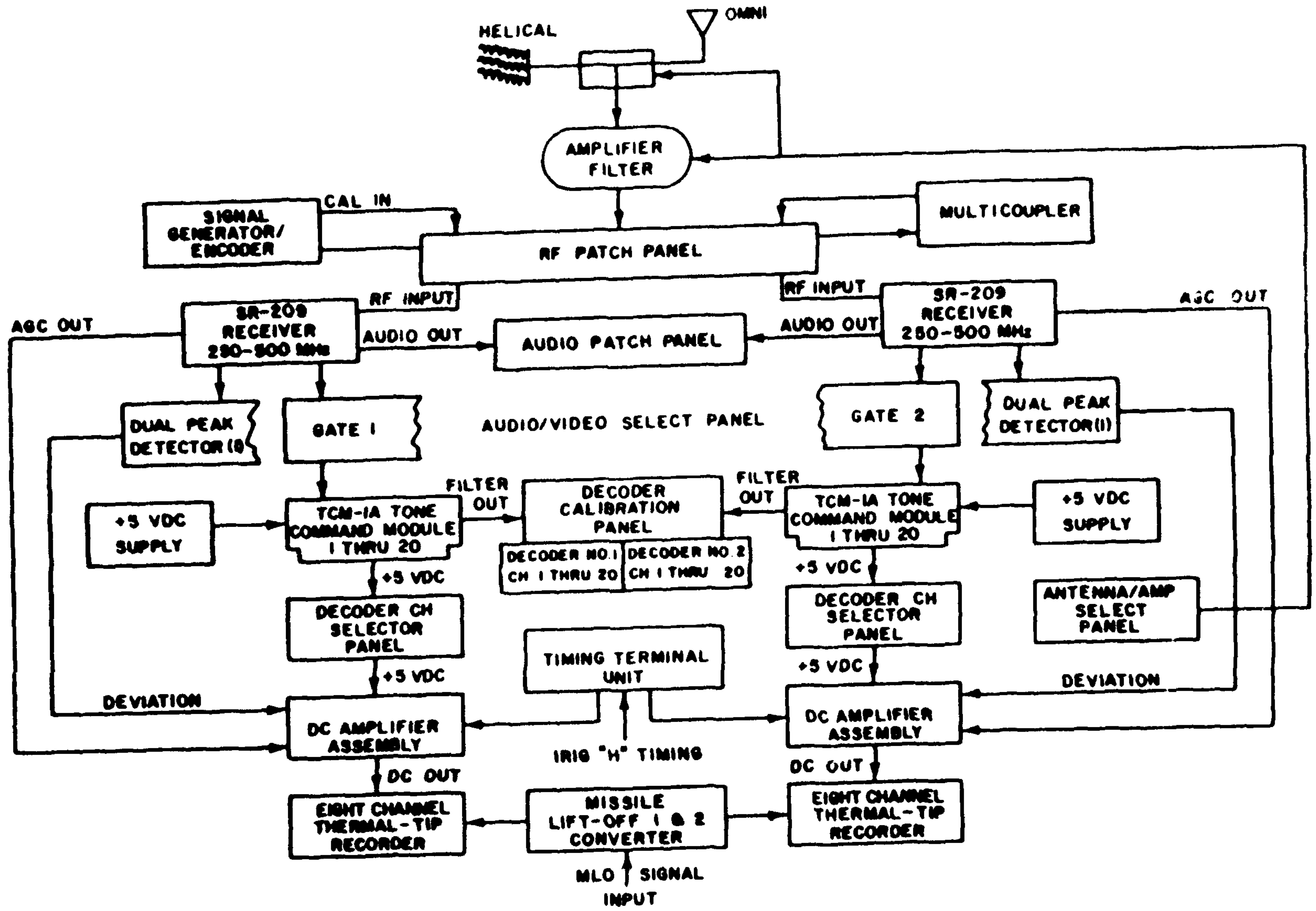


FIGURE 3-4. COMMAND TRANSMITTER MONITORING AND RECORDING SYSTEM, BLOCK DIAGRAM

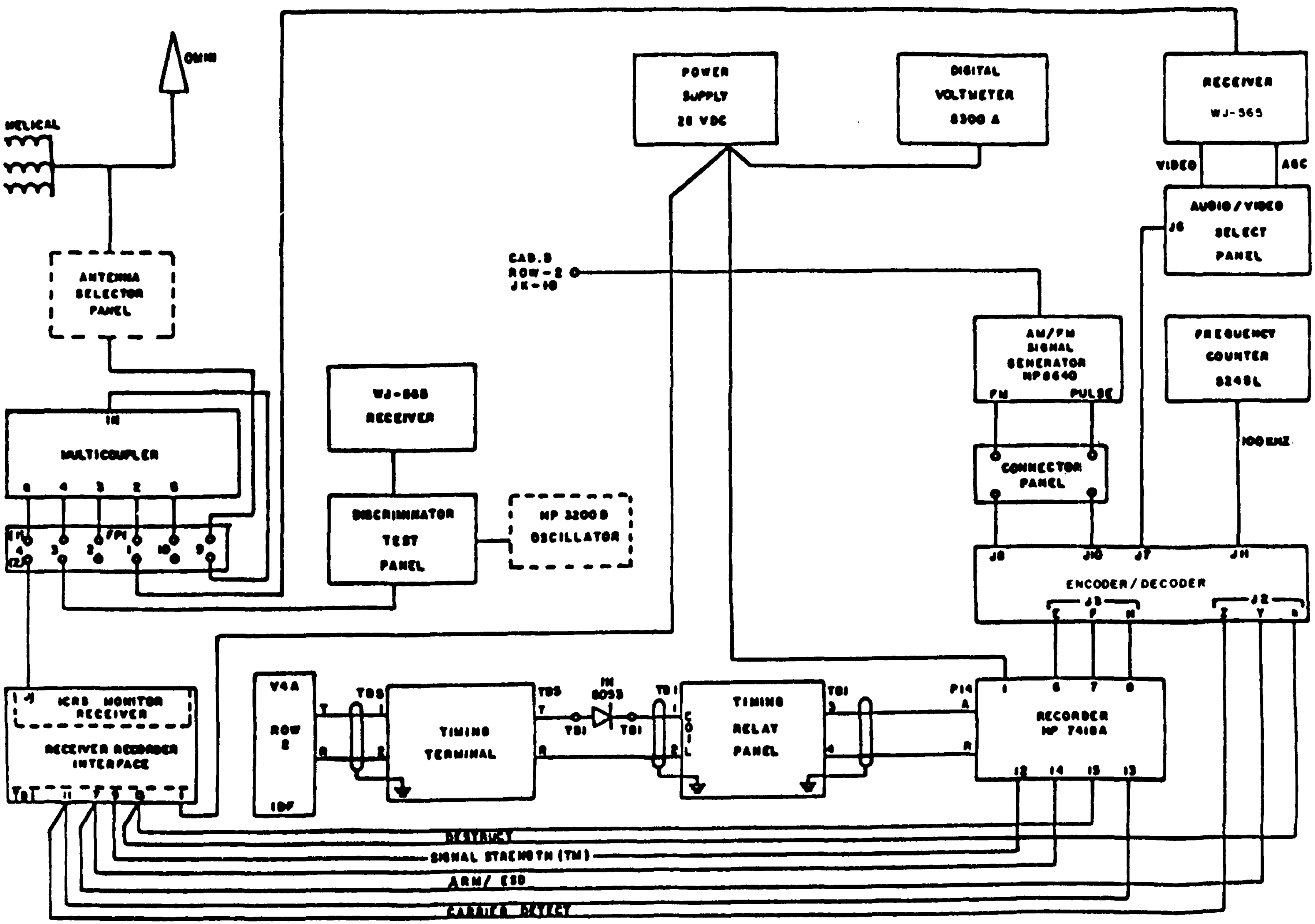


FIGURE 3-5 ICRS TEST STATION. SYSTEM BLOCK DIAGRAM

(3.3.4 cont'd)

function outputs, transmitted command, signal strength, and IRIG-H timing signals on a direct-write recorder.

The system is designed to monitor and record the CT transmission of a selected site. The monitored signal is fed into an isolated precalibrated ICRS receiver similar to the unit in actual missile flight. Test points are established across the relays of the receiver under test whose operation is required for execution of command transmitted. The voltages developed across these relays are recorded and analyzed to determine command transmitter signal quality. Figure 3-5 is a block diagram of the ICRS Test Station.

3.3.5 STS COMMAND MESSAGE MONITORING SYSTEM

The STS Command Message Monitoring System provides the Frequency Monitoring Station with the capability of monitoring and decoding the Command Transmitters while operating in the STS mode. The system operates in sequence, capture, and real time modes. All equipments necessary for pre-operational calibration are included in the system. System responses to messages are displayed on a color CRT and are also printed on a high-speed, dot matrix, 80 column printer. The system is also capable of outputting STS messages. All system measurements meet, or exceed, NASA signal control specifications. (See figure 3-6.)

Figure 3-6. STS Command Message Monitoring System

3.3.6 FM DEVIATION MEASURING SYSTEM

Figure 3-7 shows the FM Deviation Measuring System. The system is designed to measure the level and frequency of any of the command transmitter tones, as well as the center frequency, FM deviation, and apparent bandwidth of received signals. The FM Deviation Measuring System is used primarily in conjunction with the Command Transmitter Monitoring and Recording System and ALCS Monitoring/Measuring support. In addition, a DEI Model TR711 Receiver equipped with deviation meter provides quick look deviation measurements for ALCS support. Frequency range is limited to tuners available (55-260 MHz and 215-315 MHz). An HP Model 8901A Modulation Analyzer, interfaced with a WJ 565 Receiver IF Output, also provides quick look digital display of measured FM deviation.

3.3.7 EXTENDED RANGE MONITORING SYSTEM

The Extended Range Monitoring System is used to protect WSMC programs and Base support elements from unintentional interference by providing monitoring, measurements, and direction finding (DF) capabilities in the 20 MHz to 1000 MHz range.

Visual display of received signals is provided by four Watkins-Johnson 565 Receivers incorporating built-in signal monitors and tuning heads. Ranges of the tuning heads are: 20 - 90 MHz, 90 - 260 MHz, 235 - 500 MHz, and 490 -1000 MHz.

Direct frequency measurements are accomplished by a four-channel Watkins-Johnson Model DRO-311 Frequency Counter coupled to the WJ 565 Receivers. The counter provides a six-digit display of the frequency to which the selected receiver is tuned with accuracy of ± 1 kHz over the entire tuning range. Selectable four-channel digital automatic frequency control circuits (DAFC) in the counter lock the local oscillator in the tuning head in each of the four receivers to the counter in 1 kHz increments, resulting in receiver stability that approaches that of the extremely accurate reference source in the counter.

A carrier-operated relay (COR) circuit in the WJ 565 Receiver provides two sets of double-pole, double-throw relay contacts available at a rear-apron terminal strip. An adjustable threshold control sets the sensitivity level of the COR. Audio squelch is also provided by the COR threshold control. Figure 3-8 shows the block diagram of the system.

3.3.8 HF MONITORING AND TELETYPE SYSTEM

The Teletype Monitoring System may be connected by the patching facilities shown in Figure 3-9 to the high frequency (HF) receiver (51S-1 or R2174(P)/URR) to monitor incoming teletype frequency shift keying (FSK) at either 60, 75, or 100 words per minute. The teletype printer is the Teletype Corp., Model No. 28. The frequency shift converter, Type CV-89A/URA-8A, interfaces the HF receiver and teletype printer.

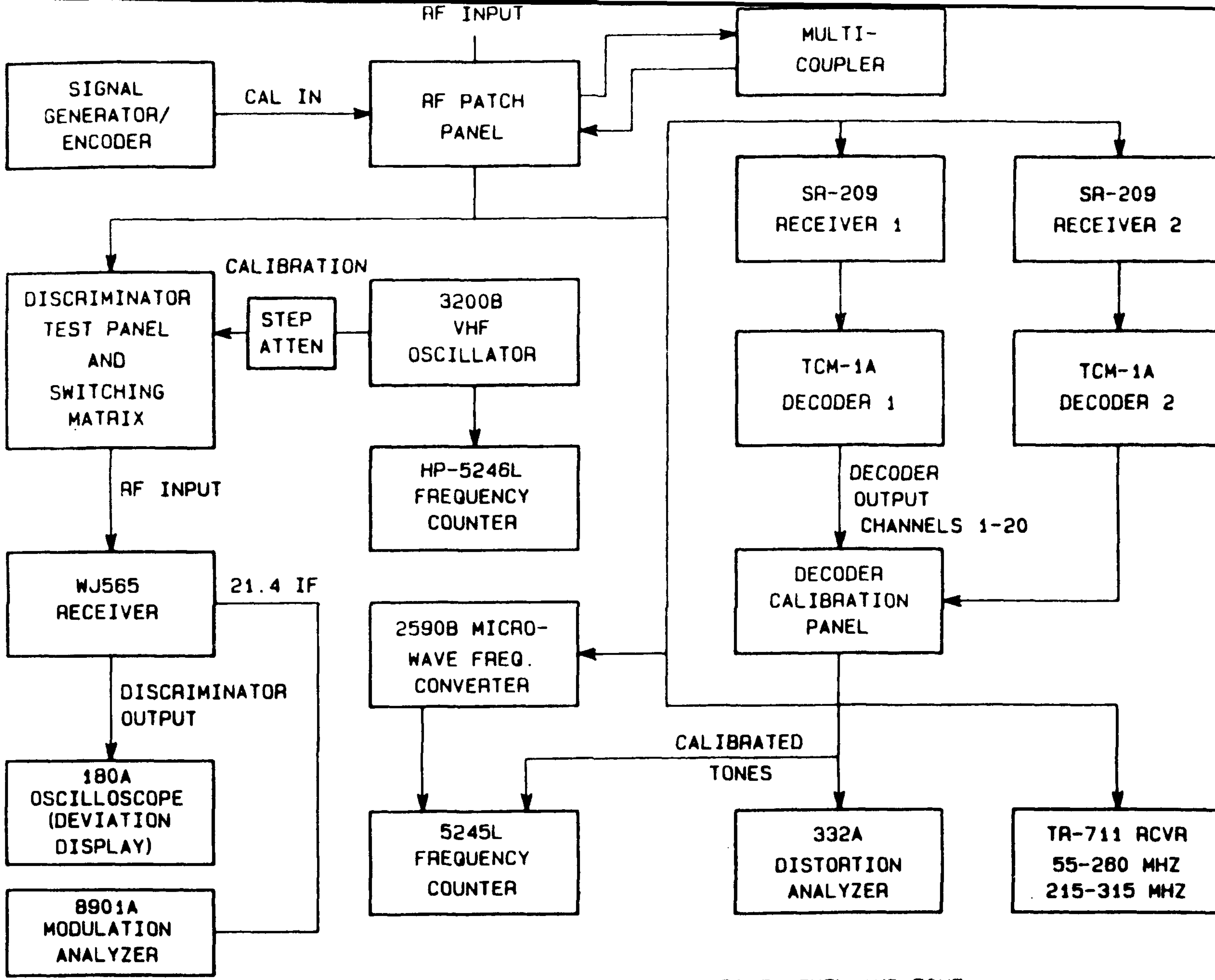


FIGURE 3-7. FM DEVIATION, TONE LEVEL AND TONE FREQUENCY MEASUREMENTS SYSTEM

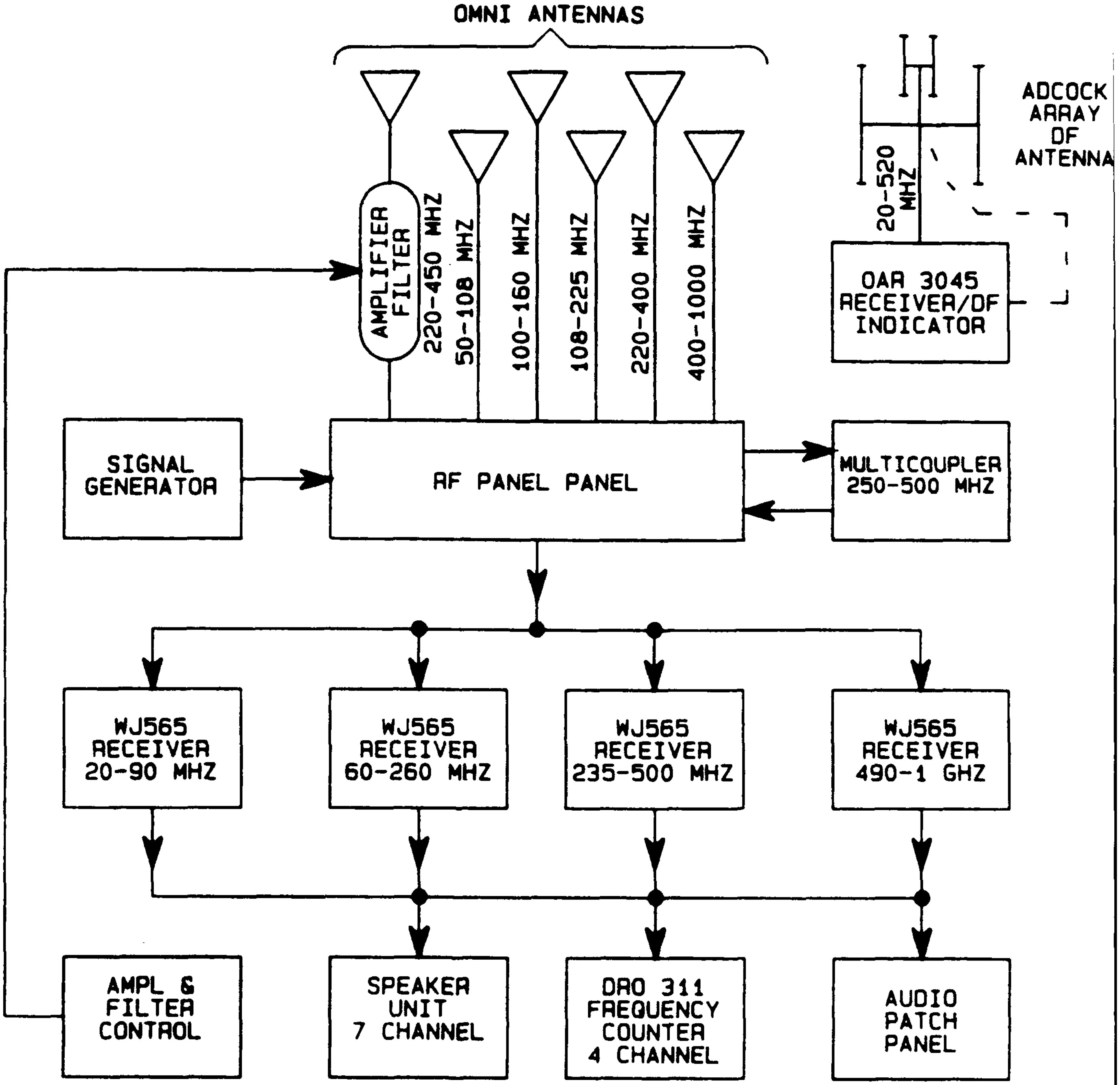


FIGURE 3-8. EXTENDED RANGE MONITORING SYSTEM, BLOCK DIAGRAM

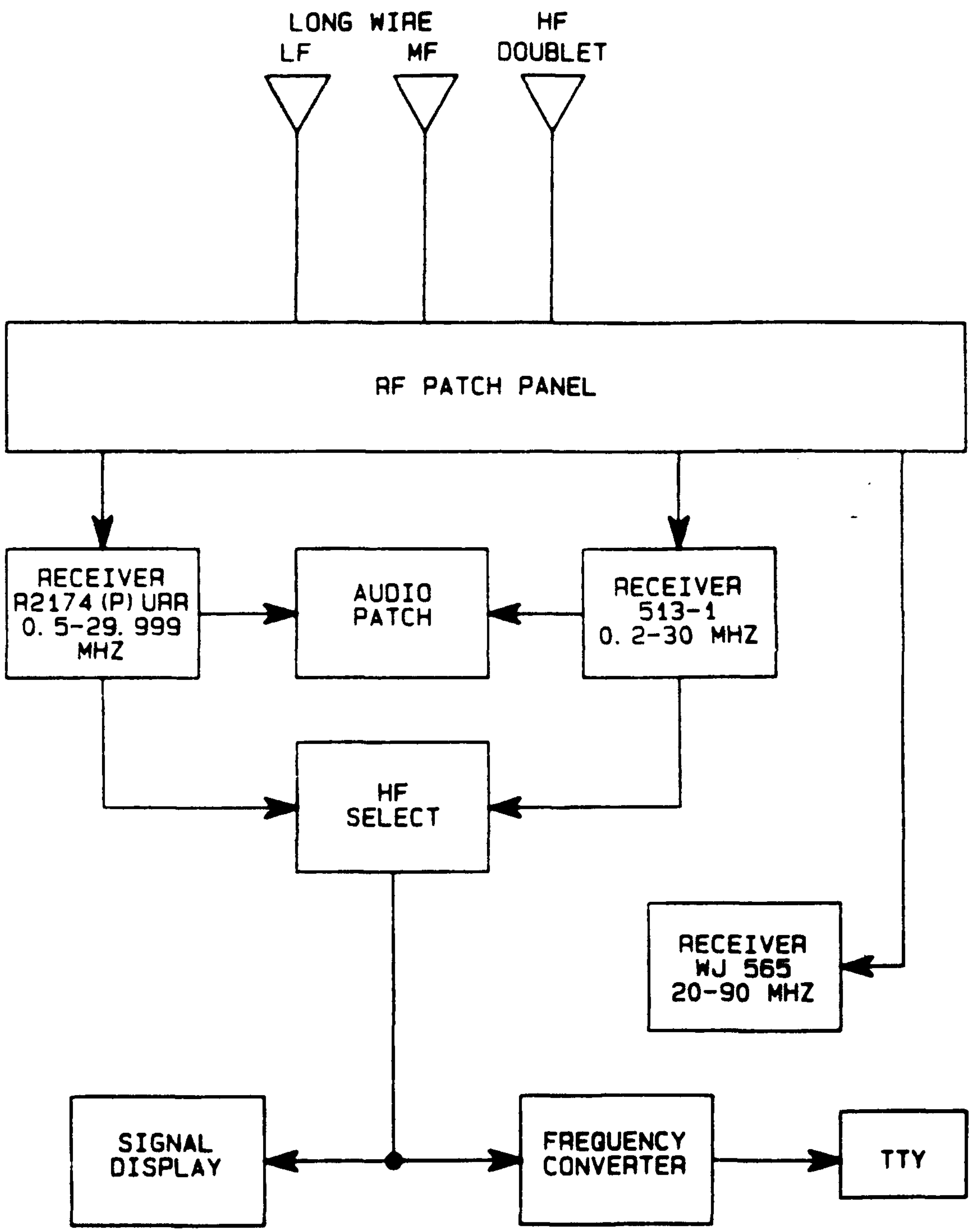


FIGURE 3-9. HF MONITORING AND TELETYPE SYSTEM, BLOCK DIAGRAM

3.3.9 AUDIO RECORDING SYSTEM

The Audio Recording System consists of three dual-channel audio magnetic tape recorders. The audio portion of intercepted signals is connected through the patch bay and amplifiers (Type AM-413) to the magnetic tape recorders. Signals received in the range of 200 kHz to 18 GHz carrying audio information may be recorded.

3.3.10 COMMUNICATIONS

A system of administrative and operational telephones; i.e., direct-lines, range trunks and conference networks, enable FMS to communicate with other operational elements of the FCA and Instrumentation Systems.

A public address countdown circuit and countdown indicator provide station personnel with real-time operational information. Accurate time is provided by a Systron-Donner Universal Time display fed by IRIG "B" timing from the WSMC Timing Center.

3.4 SYSTEM CAPABILITIES

The following subparagraphs will list system capabilities and, where applicable, major equipment specifications will be presented.

3.4.1 FREQUENCY MEASUREMENT RANGE

The frequency measurement range of FMS is from 200 kHz to 18 GHz.

3.4.2 ACCURACY OF FREQUENCY MEASUREMENTS

Frequency measurement accuracy is basically dependent upon the accuracy of the Hewlett-Packard Model 5245L Electronic Counter and associated Model 5253B Frequency Converter.

a. Accuracy: $\pm$ 1 count, $\pm$ time base accuracy.

b. Internal Time Base Accuracy: (Short-Term) - less than 2 parts 10^{10} rms with measurement averaging time of one second under constant environmental and line voltage conditions.

c. The Micro-tel MSR 903 Surveillance System has a frequency measurement accuracy of $\pm$ 100 kHz. The FCS-904 Frequency Counter/Synthesizer allows precise digital control (10 kHz resolution) when operating with the MSR-904A Receiver.

d. Frequency measurement accuracy for the WJ-565 Receiver DRO 311 Frequency Counter Combination (20 -1000 MHz) is $\pm$ 1 kHz.

e. Frequency resolution of the SCR7220 20-1200 MHz Receiver is 1 kHz, synthesized.

3.4.3 DIRECTION FINDING RANGE AND ACCURACY

a. 0.5 GHz - 18 GHz ± 0.2 degrees High Speed Rotating (5 - 300+ RPM) circular polarization. (NOTE: The 12 - 18 GHz range does not have preamplifier interface with the radar surveillance receiver system).

b. 1 GHz - 18 GHz, ± 2 degrees, High Speed Rotating with IEEE 488 option. (NOTE: Rotation speed is 1 - 300 RPM; Sector Mode: Width 4-358 degrees, Scan Rate 1-30 degrees/sec., min. This is part of the 20 MHz - 18 GHz Surveillance System.)

c. 1 GHz - 12 GHz, ± 2 degrees, 45 degrees offset polarization/6' Reflector.

d. 300 MHz - 3 GHz, ± 2 degrees, RH Circular/6' Reflector.

e. 300 MHz - 3 GHz, ± 2 degrees, LH Circular/6' Reflector.

f. 20 MHz - 520 MHz, ± 1 degree, vertically polarized Automatic DF System. Adock-Antenna Array.

g. 90 MHz - 1 GHz, ± 30 degrees (± 5 degrees, resolution on fixed amplitude/location signals) log periodic with selectable horizontal/vertical polarization.

h. 215 MHz - 265 MHz, ± 5 degrees, Quad Helical.

3.4.4 TYPES OF RF EMISSIONS

a. Amplitude Modulation (AM).

b. Frequency Modulation (FM).

c. Continuous Wave (CW).

d. Modulation Continuous Wave (MCW).

e. Pulsed Emissions (P).

The ability of the FMS to analyze Pulsed Emissions (P) is in the frequency range from 20 MHz to 18 GHz; pulse widths exceeding 0.1 microseconds and pulse repetition frequencies in the range between 12.5 to 10,000 pps.

3.4.5 RECORDING CAPABILITIES

The audio and stripchart recordings are produced at FMS by the following units of equipment whose capabilities are individually described below:

a. Three each Ampex Model AG500 dual-channel 1/4 inch Magnetic Tape Recorders provide Audio Recordings on 7 inch reels

(3.4.5) containing 1200 feet of magnetic tape and have the following response characteristics at the indicated speeds:

(1) 7-1/2 ips: ± 2 dB, 60 to 10,000 Hz.

(2) 15 ips: ± 2 dB, 30 to 18,000 Hz.

b. Three Thermal Tip Recorders produce the recorded trace with heater styli on heat-sensitive Permapaper and have the following characteristics:

(1) Channels: Eight (8).

(2) Timing: Internal 1 second and 1 minute or externally applied from the WSMC Timing Center (IRIG "H")

(3) Speed: ZF 8000: Microprocessor controlled from 1 mm/hour to 250 mm/second in integer increments from 1 to 250, plus 500 mm/second entered from panel mounted keypad.
HP 7418A: 0.5, 1, 2.5, 5, 10, 25, 50, 100, and 200 mm/second ±1%.

(4) Frequency Response: ZF8000: Flat within 1 dB to 50 Hz 40 mm. Flat to 1 dB at 10 divisions or 8 mm peak-to-peak at 100 Hz. HP 7418A: Flat within ±0.5 dB from dc to 50 Hz. Down less than 3 dB at 100 Hz.

(5) Event Marker: Two (2). Missile Lift-Off (MLO) 1 and 2. CT Recorders 1 and 2 only.

3.4.6 POWER

The FMS is equipped with 115 Vac commercial power and a 115 Vac 65 kW standby generator for use in the event of a commercial power failure. The generator operates automatically and provides all site requirements except air conditioning (including heating). Equipment high voltage restoration time is approximately two minutes when the standby generator is used.

3.5 RECORDS AND OPERATIONAL DOCUMENTATION

The FMS produces and maintains, for a 30-day period, records and operational documentation which are available to authorized agencies for correlation and analysis purposes. These include, but are not limited to, the following:

a. Daily schedules.

b. Monitoring and operational logs.

c. Stripcharts of monitored CT functions (180 days for launch operations).

d. Magnetic tapes of receiver audio.

e. Operational Checklist (OCL).

SECTION 4

FCA MOBILE VANS

4.1 RF MEASUREMENT VAN

This mobile monitoring van, designated RF Measurement Van No. 1, is a 27-foot motor home type van. The system is equipped for field deployment, and is completely self contained, having a motor generator to supply technical power, air conditioning, and heating. (See Figure 4-1).

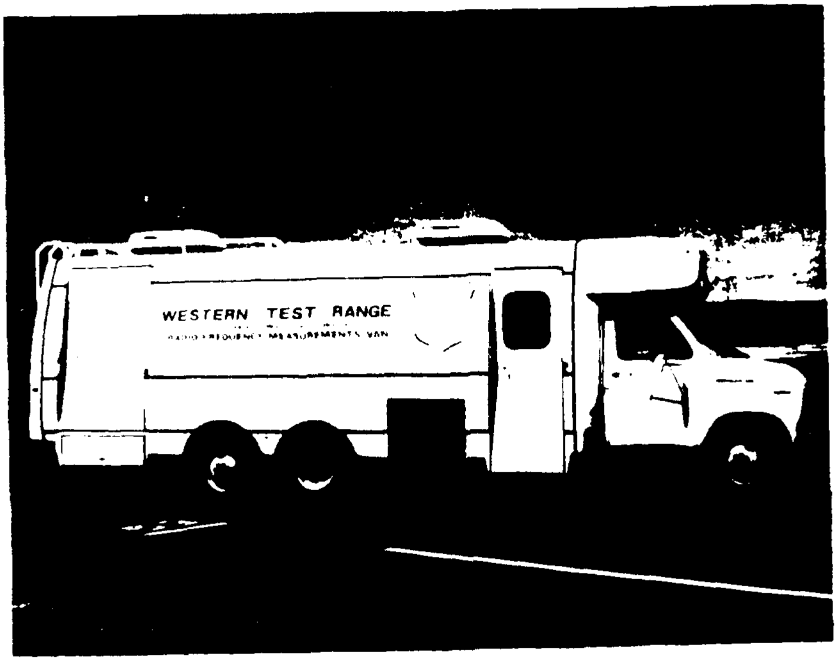


Figure 4-1. RF Measurement Van

The system is designed primarily to support field intensity measurements, closed circuit frequency radiation leakage tests, path loss studies, and radio frequency interference investigations. When not in use, the van is normally stationed at the Vandenberg FCA facility, adjacent to Building 1559.

4.1.1 FUNCTIONS

RF Measurements Van is equipped to perform the following functions:

- o Spectrum Surveillance
- o Signal Analysis
- o Frequency Measurements and Monitoring
- o Recording

(4.1.1 cont'd)

The system is capable of receiving, recording and analyzing AM/FM voice signal, CW, FSK, multiplexed signals, pulse-type signals, and telemetry signals in the frequency range from 20 Hz to 18 GHz.

4.1.2 SPECIFICATIONS

FREQUENCY MEASUREMENT RANGE: 20 Hz to 18 GHz.

FREQUENCY MEASUREMENT ACCURACY:

a. $\pm$ 1 count, $\pm$ time base accuracy of HP Model 5245L Electronic Counter and associated models 5253B, 5254A, and 5255A Frequency Converters. Frequency range from 150 kHz to 12.4 GHz.

b. Internal time base stability: Aging Rate: less than 3 parts in 10^9 per 24 hours. Temperature: less than 10 $\pm$ 2 parts in 10^{10}, -20 deg. C to +55 deg. C.

c. In the range of 100 Hz to 18 GHz, using the Hewlett-Packard Model 8566A Spectrum Analyzer, the accuracy is $\pm$ 1.2 percent of frequency span.

NOISE & FIELD INTENSITY ANALYSIS: Range: 20 Hz to 1.0 GHz using the combination of the Electro-metrics EMC10 the Ailtech Model NM25T, NM7, NM 17/27 and NM37/57 EMI Receivers, and 1 to 18 GHz using the Ailtech NM67 receiver.

SPECTRUM SURVEILLANCE: Range: 50 Hz to 18 GHz using the HP 8566 Spectrum Analyzer.

FM DEVIATION MEASUREMENTS: Frequency range: 14 kHz to 20 GHz. Deviation to maximum of approx. 2 MHz depending upon FM video input from receiver.

RECORDERS: Various Hewlett-Packard Stripchart Recorders are available for use for special requirements with any of the system receivers. A time code generator is provided in the system, permitting the recording of real-time or elapsed time events.

4.2 TRANSPONDER TEST VANS (TTV)

The RF Measurements Laboratory operates and maintains two mobile "SHF-band" (5400-5900 MHz) transponder evaluation facilities, designated Transponder Test Van #1 (TTV-1) and Transponder Test Van #2 (TTV-2). These vans are used for field testing and troubleshooting of range user transponders. Such tests insure that transponders are in compliance with range standards before being released for operational uses. Transponder evaluations and compatibility tests can be performed on both non-coherent (dual frequency) or coherent (single frequency) systems. Seventy-foot portable towers are available for use in areas requiring an elevated and unobstructed electronic view of specific VAFB launch and test facilities. Tower erection time is approximately thirty minutes.

4.2.1 TRANSPONDER TEST VAN #1 (Figure 4-2)

This van is fully operational, providing open and closed-loop field testing of 5.4 GHz - 5.9 GHz beacons and transponders. In the open loop configuration, the system's 10 watt output is capable of interrogating transponders at a distance of several thousand yards. The system itself consists of a multi-pulse generator, modulator, TWT amplifier, "SHF-band" attenuator and frequency measuring unit, along with ancillary oscilloscopes, digital counters, power meters and time interval counters. A three-foot parabolic dish antenna is used during open-loop interrogation/reply measurements.

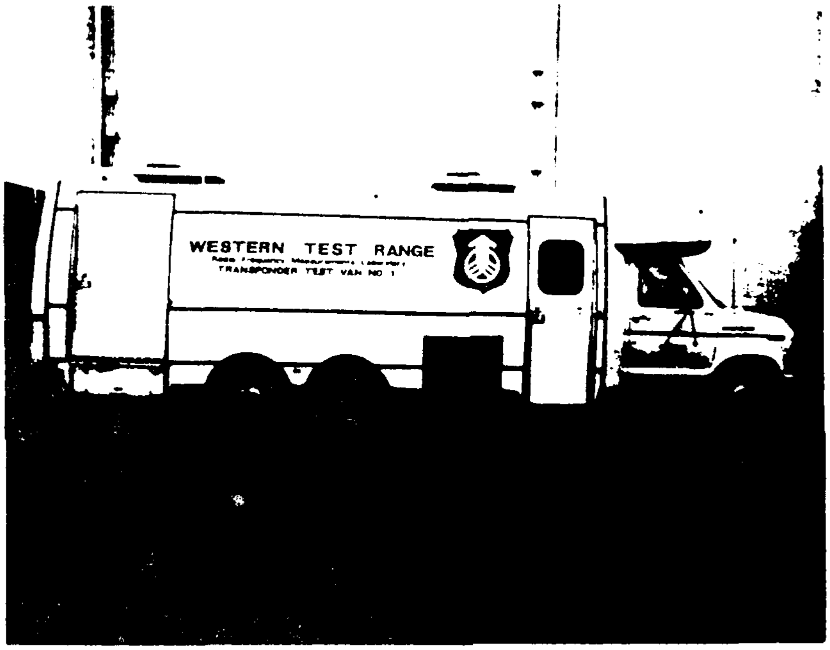


Figure 4-2. Transponder Test Van #1

4.2.2 TRANSPONDER TEST VAN #2 (Figure 4-3)

This van is fully operational, providing essentially the same services as provided by Transponder Test Van #1, the major difference being its automated features. The automated system is controlled by a Hewlett-Packard 9845B Desk Top Computer which limits the system operation to automatic mode only. Tailored software drives the computer-controller. The operator activates the system by entering transponder parameter data and is assisted by prompts from the software program.

The automated system consists of a time/frequency standard, frequency synthesizer, regulated power supplies, low-power transmitter, wide and narrow band receivers, pulse generator, bus-controlled step-attenuators, frequency and time interval counters, phase correlator, velocity analysis

4.2.2 (cont'd)

unit, peak power meter, spectrum analyzer, multi-meter, computer interface units, and a multi-programmer, all of which are IEEE-488 bus-controlled from the 9845B Desk Top Computer terminal.

Power output for interrogation is limited to +32 dBm (1.6 watt) output. A three-foot parabolic dish antenna or any of various standard gain horn antennas is used during open loop transponder testing.

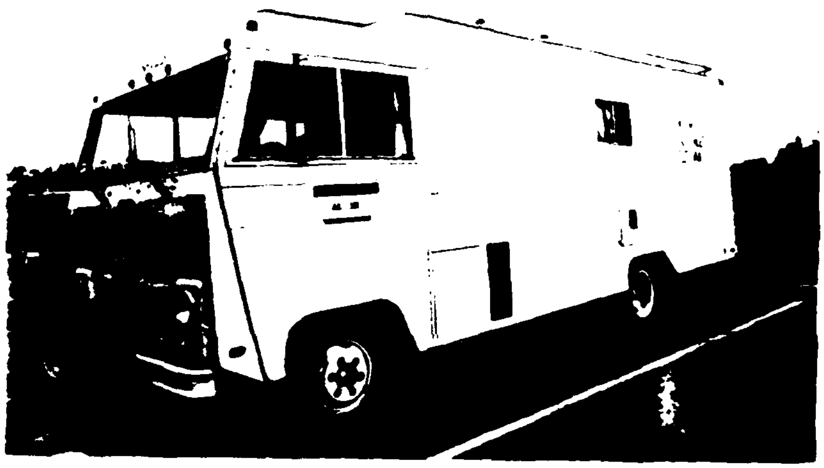


Figure 4-3. Transponder Test Van #2

4.3 COMMAND RECEIVER TEST VAN (CRTV) (FIGURE 4-4)

The Command Receiver Test Van (CRTV) is available for field tests on range user command receivers and command receiver test sets as required by WSMC Regulation 127-1. Tests are conducted in an RF closed loop system mode with test signals applied to the command receivers through the missile-borne antenna system through use of an external RF cable and antenna coupler. Performance characteristics of the command receivers are displayed and evaluated within the Command Receiver Test Van itself. If command receiver test stations are provided by the range user, RF Measurements Laboratory personnel verify that these test stations operate within the limits and specifications acceptable to Range Safety.

(4.3 cont'd)

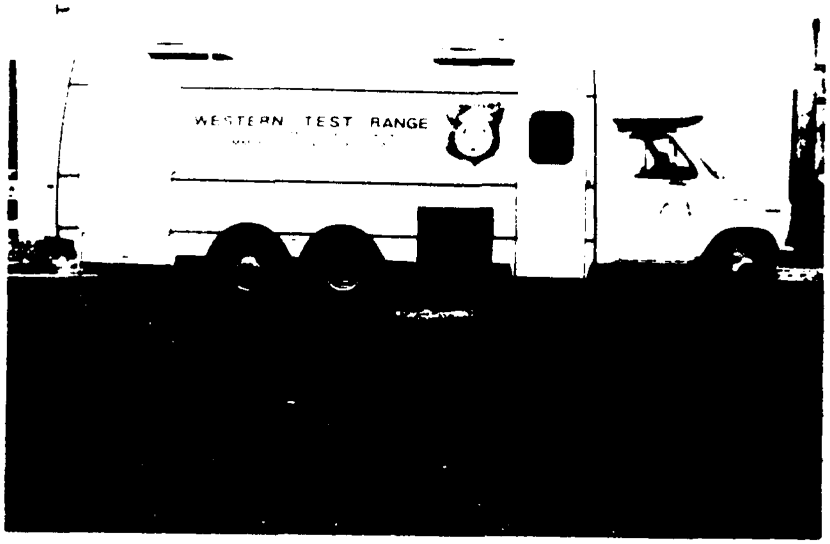


Figure 4-4. Command Receiver Test Van

The system is designed to operate at the range user facility or other designated areas. It is enclosed in a mobile, self-contained unit capable of operating on commercial power or self-generating power. Air conditioning is provided for van cooling and blower motors for equipment cooling.

The major components of the system are the encoder/decoder, command interface unit, remote unit, and digital interface unit. The encoder/decoder unit is used to set up and control testing of the receiver under test. It simulates a command transmitter and sends command sequences to the receiver under test and monitors the receiver response to the commands. The commands transmitted by the encoder/decoder are monitored by the special purpose receiver, which furnishes inputs to the encoder/decoder for command transmission verification. The unit contains visual indicators for transmission, verification, and receiver response.

4.4 RANGE SAFETY TEST VAN (RSTV) (Figure 4-5)

The Range Safety Test Van serves as a mobile shelter for the command receiver and SHF transponder testing at remote locations on Vandenberg AFB and at other off base locations.

The command receiver and SHF transponder test sets are individually housed in dual lightweight mobile racks for easy off loading. The RSTV supports bench level testing as well as preflight testing. The van has separate onboard AC generators for environmental services and instrumentation. When not providing operational support, the RSTV is located at Bldg. 7011.

(4.4 cont'd)

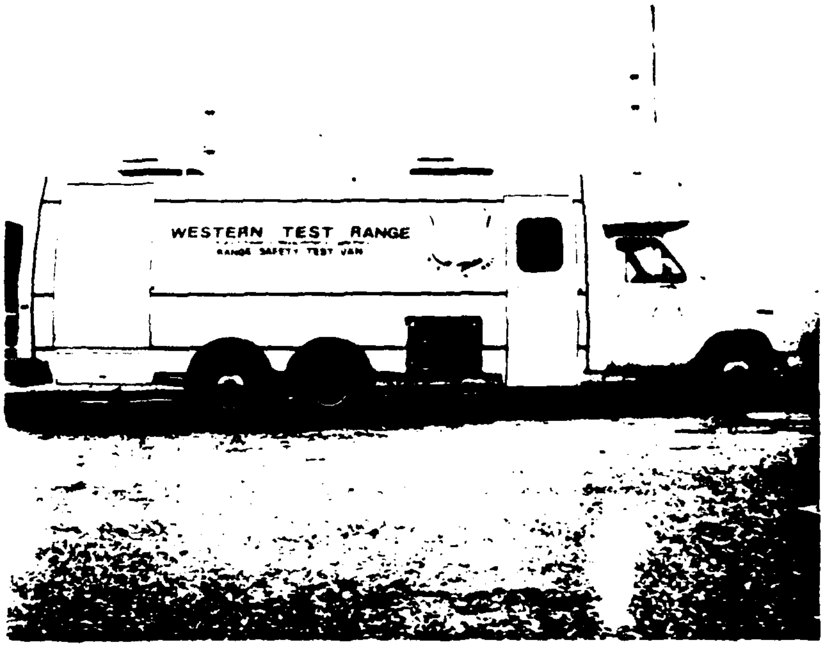


Figure 4-5. Range Safety Test Van

SECTION 5

RADIO FREQUENCY MEASUREMENTS LABORATORY

5.1 GENERAL

Collocated with the FCAC in Building 7011, the Radio Frequency Measurements Laboratory (RFML) is an integral unit of the FCA System. It provides radio frequency engineering services that minimize or eliminate problems of electromagnetic compatibility that cannot be controlled by frequency assignment, scheduling, or coordination.

Unique RF measurements that cannot be provided by the fixed monitoring station, specialized RF measurements, and analysis in the 100 Hz to 18 GHz frequency range are among the capabilities of the Radio Frequency Measurements Laboratory.

Additionally, the RF Measurements Laboratory provides a flight qualified technical air crewman when required for periodic support aboard government or leased aircraft during the conduct of airborne RF measurements and range tests.

The workload of this section is monitored and coordinated by the Range Frequency Management Branch of the Data Transfer Division. All work assignments other than those directed by Operations Directives must be approved by the Frequency Manager.

5.2 FUNCTIONS

The Radio Frequency Measurements Laboratory performs the following specific functions in support of the Test Range:

- Closed loop certification tests
- Spectrum signature and radiation data of radio/radar transponders
- Range safety transponders confidence and performance tests
- Command receiver confidence, performance, and certification tests
- RF emitter tests to IRIG and range standards
- Electromagnetic interference location, identification, and analysis.
- Command transmitter confidence and certification tests for ICRS support at the FMS (Bldg. 441) location.
- Certification of user's command receiver test stations

(5.2 cont'd)

- o Unique RF tests and measurements that may be required by range and range user agencies
- o Operation and maintenance of all FCA vans
- o Range calibration and special test flight support including design, configuration, calibration, and in-flight operation and analysis functions.

Support functions rendered to the Center Technical Support Contractor (CTSC) include, but are not limited to, the following:

- o RF system component tests of antennas, filter, preamplifiers, receivers, coaxial cables, waveguides, multicouplers, duplexers, and downconverters
- o RF system test and evaluation of system gain, noise figure, pattern, attenuation, VSWR, merit figure, bandwidth, power output and stability, frequency accuracy and stability, deviation, and system delays
- o Time domain reflectometry tests of coaxial cables
- o Special projects: measurement methods, system requirements, and component and system acceptance tests
- o Design and development of specialized antenna systems and specialized measurement systems
- o System radio frequency interference and electromagnetic interference tests, analysis, and resolution

Certification, tests, and evaluation which pertain to the specified functions and have wide application will be described in brief detail in the following subparagraphs.

5.2.1 CLOSED LOOP CERTIFICATION

Closed loop operation on the Test Range is defined as the operation of an RF generating system with all radiating portions fully shielded. All closed loop radiations are officially scheduled, as in open circuit operations, and are permitted only after the system has been certified by the Range Frequency Manager as meeting the required specifications. Any detection of radiation automatically revokes the system's closed loop certification and re-certification of the system becomes necessary.

Refer to WSMC Regulation (WSMCR) 100-7 Chapter 10 for standards, specification, and scheduling as applicable to closed loop certification.

5.2.2 SHF-BAND TRANSPONDER EVALUATION

The Radio Frequency Measurements Laboratory maintains and operates a threefold capability for test and evaluation of SHF transponders:

1. A Laboratory Transponder Test System (LTTS) is located in a 100 dB screen room within Building 7011 to perform complete WSMC Form 89 or Form 189 evaluations on both coherent and non-coherent transponders.

   The LTTS provides essentially the same services as the TTV-2 (Figure 4-3) but utilizes the facility power source only. While intended for testing purposes at the RF Measurements Laboratory, the racks could be relocated to another facility for emergency use.

Figure 5-1. Laboratory Transponder Test System

(5.2.2 cont'd)

2. Four portable radar simulators are available for troubleshooting and testing in inaccessible areas, and for transponder installations and checkouts at remote locations. The units are transported by a general purpose RF Measurements Laboratory Van, or may be hand-carried to the locations where they are to be used. Measurement accuracy is limited, but adequate for the assigned tasks. See Figures 5-2 and 5-3 for a view of two of the portable radar simulators.

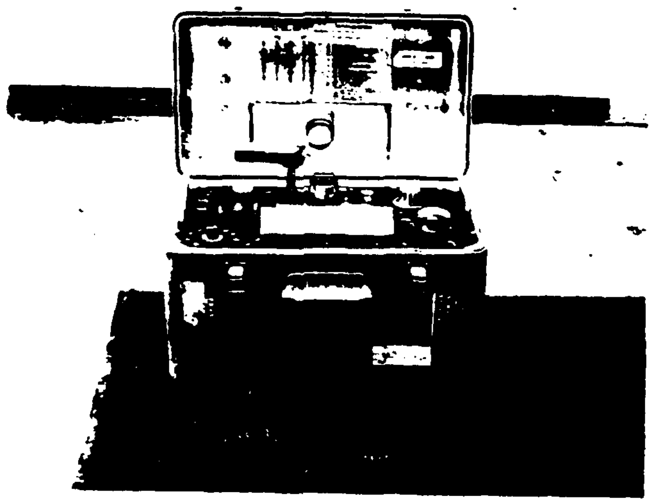


Figure 5-2. VEGA Model 616

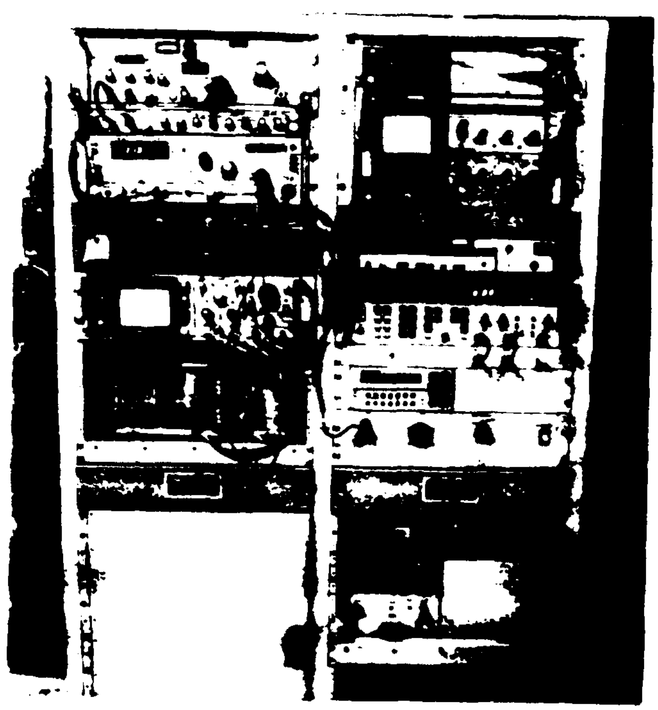


Figure 5-3. FEC Model PTTS-5000

(5.2.2 cont'd)

3. The Transponder Test Vans (TTV) provide the range and range users with a mobile field transponder check out facility having the same capabilities as the fixed test facility located in Building 7011. See Section 4-2 for a complete description of the TTV.

5.2.3 COMMAND RECEIVER CERTIFICATION

The Radio Frequency Measurements Laboratory performs tests on missile-borne command receivers to assure compliance to IRIG, Range Safety, and manufacturer's specifications. Receiver characteristics of sensitivity, stability, bandwidth, decoder logic, input current, deviation sensitivity and compatibility, AGC curve, capture ratio, command function output delay, filtering, and command output voltage drop are checked and certified to be within specified tolerances prior to release of the receivers for operational use. The tests are performed in conformance with military requirements and are valid for a period of 90 calendar days. Command receivers are tested within 90 days prior to actual launch. The command receiver flight certification test area is shown in Figure 5-4.

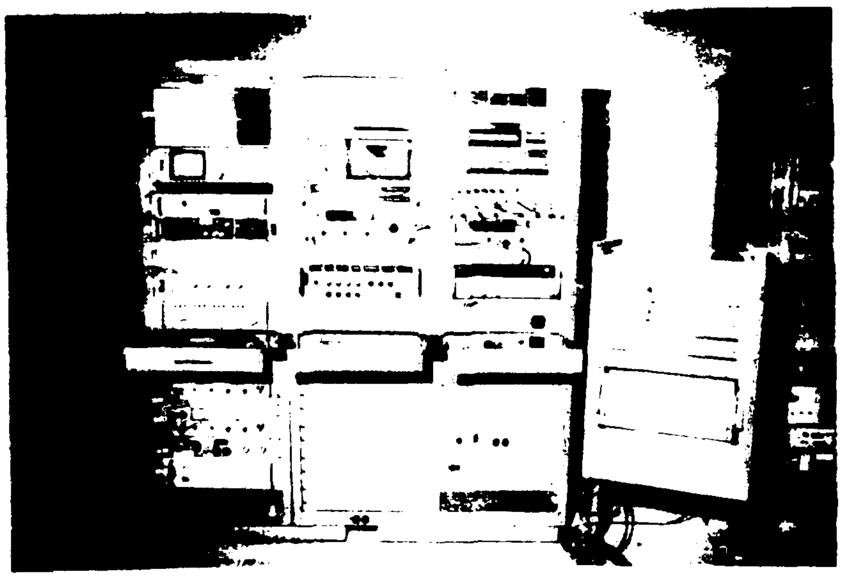


Figure 5-4. Command Receiver Test Verification Facility #2

Non-recurring acceptance or "type approval" testing of new command receivers is occasionally required. The tests performed are extensive and, in addition to the 90 day certification tests, include: compatibility testing, operating bandwidth, continuous wave (CW) bandpass characteristics, and deviation sensitivity with respect to supply voltage.

(5.2.3 cont'd)

Type approval testing is performed with specialized test equipment configurations within the command receiver flight verification test area.

The descriptions and requirements for missile flight termination systems, including command control transmitters, may be found in WSMC Regulation 127-1 as amended.

As an ancillary task to command receiver certification functions, the RF Measurements Laboratory performs operational monitoring and checkout of command transmitters when using the Improved Command Receiver System (ICRS) mode of operation. The task is performed at the Frequency Monitoring (Building 441) facility, and requires the operation of an ICRS receiver during command transmitter readiness checks prior to and during launch count-down exercises.

The mobile Command Receiver Test Van provides field testing on range user command receivers and command receiver test sets. Refer to Section 4.3 for a description of this facility.

5.2.4 RADIO FREQUENCY SPECTRUM ANALYSIS

As a part of the preoperational FCA System program, spectrum studies are made of range user transmitting equipment to evaluate the interference potential of the transmitters and ascertain compliance with range frequency stability and harmonic and spurious suppression requirements. Requirements for spectrum analysis are not intended to be exhaustive studies of detailed operating characteristics.

Refer to Air Force Regulation AFR 700-14 (as revised), IRIG Document 106-86, and WSMC Regulation 100-7 for requirements and specifications as applicable to radio frequency analysis.

5.2.5 OPERATIONAL SYSTEMS TEST FACILITY (OSTF)

The Operational Systems Test Facility (OSTF), located on north VAFB, supports Minuteman and Peacekeeper operations involving UHF (2.2-2.29 GHz) telemetry transmissions. Since the fixed monitoring station on south VAFB cannot "see" all the launch facilities in the Minuteman complex, the OSTF receives and records signal strength variations, center frequency drift of the UHF transmitters, and variations in phase deviations. This site is out of the launch corridor, and provides FCA support as directed or scheduled in range documentation.

Additionally, the OSTF supports Airborne Launch Control System (ALCS) operations when scheduled. Field intensity of command signals transmitted from aircraft are monitored, measured, and recorded as appropriate. The proximity of the OSTF site to the Minuteman areas plus the specialized test equipment assures adequate support to range user requirements. See Figure 5-5 for an exterior view of the OSTF facility.

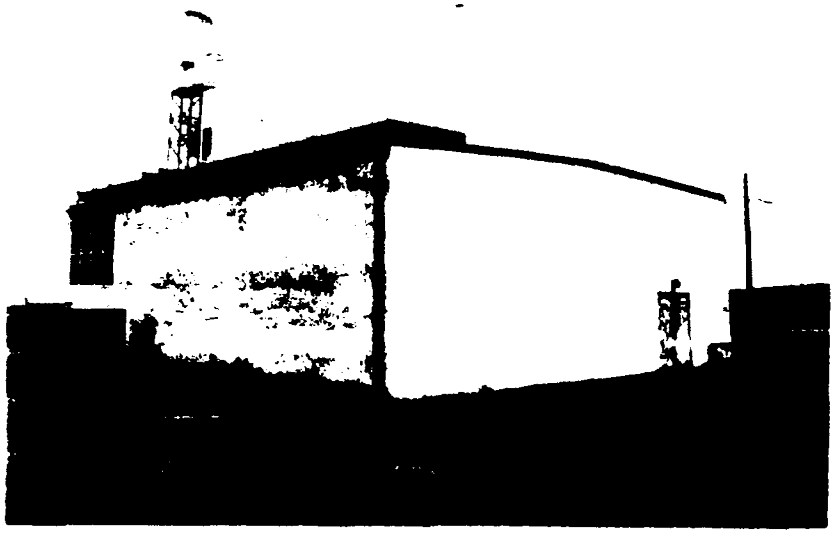


Figure 5-5. OSTF Facility

5.2.6 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY TEST FACILITY

The Radio Frequency Measurements Laboratory conducts Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) testing at the North VAFB, building 1559, facility. The test facility occupies two rooms within the high bay area of the building. The equipment room measures 15 ft. in length, 20 ft. in width, and 11 ft. in height. The equipment room is adjacent to the Anechoic Chamber, whose walls and ceilings are covered with absorptive material in order to reduce secondary emissions during electric field testing. The chamber also contains two 4-ton overhead rail mounted electric cranes. Both the equipment room and chamber are "screen rooms," and have vault-type interference proof entrance doors.

EMI and EMC testing is performed within the Anechoic Chamber. Test equipment necessary for MIL-STD 461 testing is located in the equipment room. Instrumentation and power cables are fed through an interference proof bulkhead wall panel.

The primary equipment used in EMI testing is the Ailtech NM7, NM17/27, NM37/57, and NM67 field intensity receivers having a frequency range from 20 Hz to 18 GHz.

The EMI test facility conducts EMI-EMC testing upon MIL-STD 461/462 methodology. The basic testing covers four main areas: a) conducted emissions, b) conducted susceptibility, c) radiated emissions, and d) radiated susceptibility.

(5.2.6 cont'd)

Tests are also conducted on the reflective or absorptive characteristics of various materials; e.g., paints, lacquers, etc. Other tests conducted include gain and pattern measurements of standard antennas utilized by other elements of the RF Measurements Laboratory. Refer to Figure 5-6 for interior view of the EMI-EMC facility.

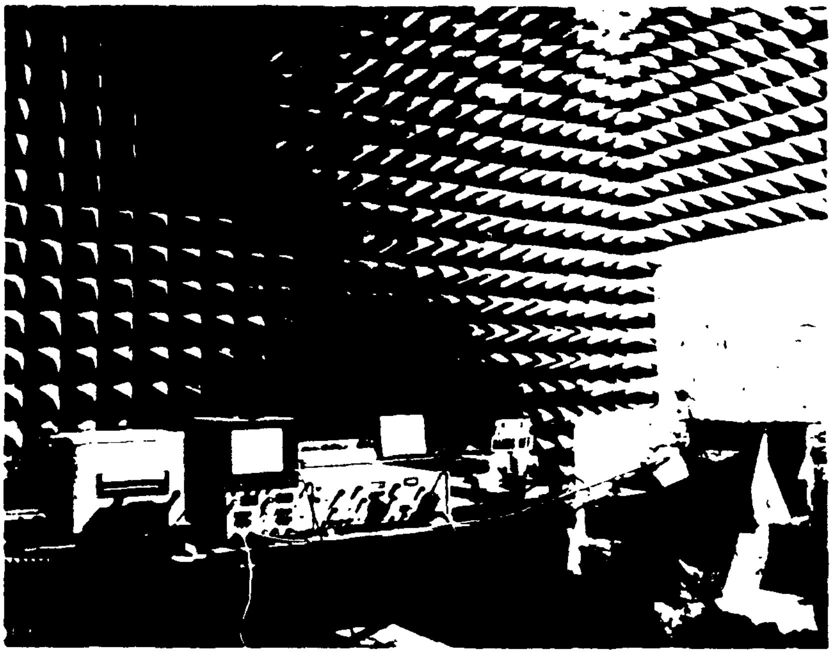


Figure 5-6. Anechoic Chamber, EMI-EMC Facility

5.2.7 RADIATION HAZARD (RADHAZ) TESTING

Potential radiation hazards from CEM equipment are due to radio frequency emanations and X-ray radiation (also referred to as non-ionizing and ionizing radiation, respectively).

The RF Measurements Laboratory conducts RF power density measurements for non-ionizing energy in the 0.01 GHz - 26 GHz frequency spectrum upon direction of the Range Frequency Manager. These measurements are made wherever engineering changes or modifications are made to high power range communications or instrumentation systems to insure that RF radiation levels are within established tolerances and do not present a RADHAZ threat to operating personnel. The NARDA Model 8608 Broadband Isotropic Radiation Monitor is used by Laboratory personnel during the conduct of these radiation measurements.

RADHAZ tests are conducted in accordance with the provisions of MIL-R-9637B, AFOSH STD 161-9, and T.O. 31Z-10-4.

5.2.5 FLIGHT SUPPORT

The RF Measurements Laboratory provides equipment, installation services, and flight-qualified personnel in support of such tasks as antenna pattern measurements, telemetry antenna testing and calibration, radar system calibration, command receiver flight checks, and special tests; e.g., airborne feasibility studies for new programs and hardware. These tasks are directed by the Range Frequency Manager in response to range or range user requirements.

Flight support is conducted aboard leased aircraft staging from the Lompoc, California airport. See Figure 5-7 for a view of the leased aircraft shown with a Range Test Van.

Figure 5-7. FCA Flight Support Aircraft

5.3 RECORDS AND OPERATIONAL DOCUMENTATION

The RF Measurements Laboratory maintains records, logs, certification information, and operational documentation which are available to authorized agencies for correlation and analysis purposes. Additionally, RF environmental information in support of the FCA document "Radio Frequency Sources at the WSMC". Data produced in response to normal operational requirements includes beacon transponder evaluation and compatibility test reports, command transmitter pen records, telemetry link evaluation records, logs and stripcharts, and A[illegible]S A/G signal strength recordings and logs.

Refer to WSMC Regulation (WSMCR) 100-7 for information pertaining to specific forms and their uses, and Air Force Regulation (AFR) 700-14 for directive authority and disposition.

SECTION 6

FREQUENCY MANAGEMENT SUPPORT SECTION (FMSS)

6.1 GENERAL

Frequency Management Support encompasses the following efforts:

- o Radio Frequency Plans, Predictons, and Engineering
- o Radio Frequency Research, Records, and Documentation
- o Reports, Utilization, and Analysis

The FMSS supports the Range Frequency Manager in the frequency management functions of allocation, application, assignment, control, and coordination.

6.2 FUNCTIONS

Specific functions of the FMSS include, but are not limited to, the following:

- o Performs frequency engineering research as directed by the Range Frequency Manager
- o Produces and maintains the Frequency Management Handbook
- o Produces and maintains the Radio Frequency Sources Document
- o Produces and maintains the Radio Frequency Authorization Document
- o Produces high frequency (HF) propagation prediction charts and reliability figures for the communications system and other special programs
- o Maintains various frequency publications; collects, correlates and stores for research purposes
- o Disseminates solar flux density measurements and solar disturbance information to range and off-range instrumentation and communication sites and users.

The major functions of the FMSS are briefly described in the following subparagraphs:

6.2.1 ELECTROMAGNETIC COMPATIBILITY ANALYSIS PROGRAM

DoD has established an agency to predict, in depth, potential interference, and to evaluate interference situations. This agency, located at Annapolis, Maryland, is the Electromagnetic Compatibility Analysis Center (ECAC). Duties of the ECAC include establishing a data base of information, a rapid analysis capability to solve specific electromagnetic compatibility problems, analysis of these problems, and providing assistance throughout the technical management of the three military services.

To obtain and maintain valid equipment parameters, the ECAC reviews requests for frequency allocations (refer to AF Regulation 700-14; WSMC Regulation 100-7, for correct forms and their completion instructions) to document equipment planned for future use by the requesting agency. Each device capable of receiving or transmitting electromagnetic energy has a unique identity number on file with the ECAC.

FMSS provides assistance to the Range Frequency Manager in the review and submission of radio frequency allocation and application requests.

6.2.2 RADIO FREQUENCY SOURCES DOCUMENT

The document "Radio Frequency Sources at the WSMC" is a tabulation of known RF sources within the Range area of operation and is prepared and published by the FMSS. The compiled data can be used to make theoretical calculations for determining power density from the radio frequency sources. In that the RF environments are not fixed and are subject to change, it is necessary to periodically review and update this data.

6.2.3 RADIO FREQUENCY AUTHORIZATION DOCUMENT

The Radio Frequency Authorization (RFA) is the primary reference document for frequency management and reflects all currently assigned frequencies authorized for use on the range. Single line entries reflect frequency classification, frequency, location, agency, emission, power, command application, authority and date of authorization, use, remarks, and expiration date. The RFA is published by the FMSS and is updated at six-month intervals to assure that the entries are current and correct.

6.2.4 WSMC IONOSPHERIC PROPAGATION PROGRAM (IONPRO/HFMUFES-4)

The propagation conditions expected to be encountered over given communications paths must be predicted in advance of operations in order to plan communications circuit operation efficiently, and to ensure that an adequate supply or complement of frequency assignments will be available to support the scheduled operation. Most long-distance communications using high frequency radio depend on the ability of the ionosphere to return the radio signals back to the earth. The ionosphere has four principal regions which affect the propagation of high frequency radio waves. Figure 6-1 shows these regions. Refer to AFR 700-14 for a comprehensive study of the ionosphere and its effect on radio propagation.

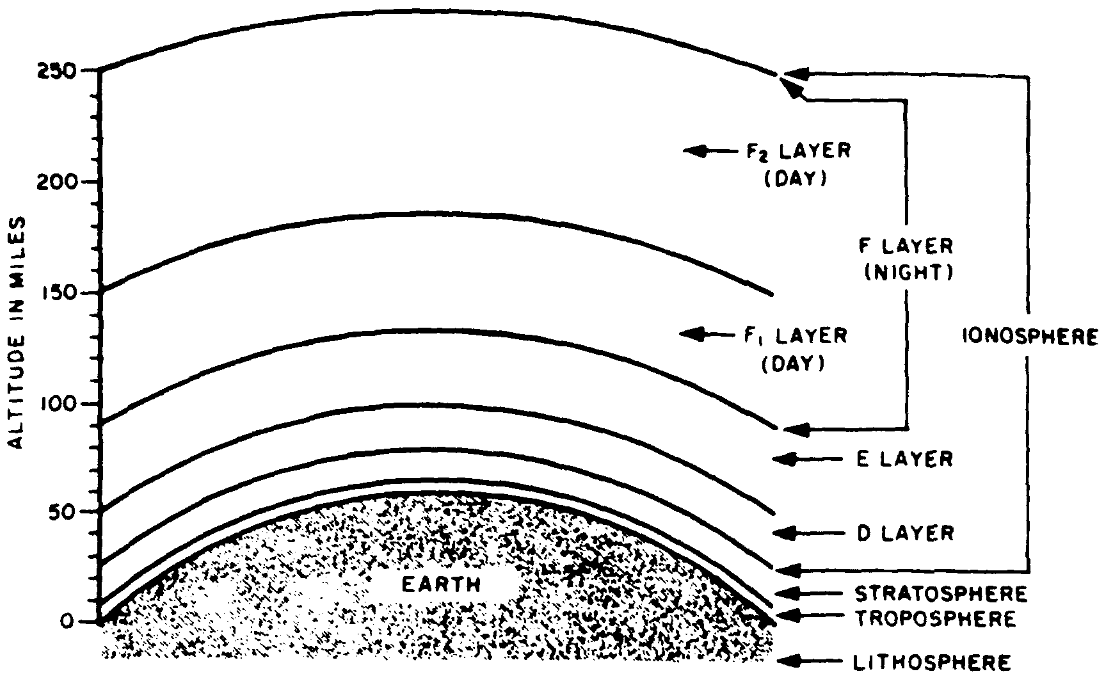


Figure 6-1. Layers of the Atmosphere

The U.S. Department of Commerce, National Telecommunication Information Agency, Institute for Telecommunication Sciences (NTIA ITS), offers ionospheric propagation data information (over selected paths) to military and civil agencies on a world-wide basis. The data is obtained through a system of numerical mappings of the ionosphere, using vertical incidence sounders. Computer techniques provide prediction information in a rapid systematic manner.

The Range Ionospheric Propagation Program (IONPRO/HFMUFES-4) is formulated utilizing the NTIA/ITS data base as applied over range radio paths and supplementary paths as dictated by scheduled operations. The data is used to directly support range HF communications by providing optimum working frequencies at any given time throughout a 24-hour period.

6.2.5 SOLAR AND GEOPHYSICAL ACTIVITY REPORTING

Solar and geophysical activity affects various military operations, including satellite surveillance, communications, and research development projects. Personnel working in these areas are concerned with the effects of variations in solar and geophysical activity on their particular sphere of operations and require periodic reports of current and estimated near-term solar conditions.

Through a cooperating network of world-wide radio, optical, geophysical and satellite observatories, data is made available via shared communications hub designated the "Continental Meteorological Data System (COMEDS)." The USAF Space Environment Support Branch, Global Weather Central at Offutt AFB, Nebraska, in association with the National Oceanic and Atmospheric Administration (NOAA), receives data from the various observatories and makes it available to customer/agencies requiring this data in their area of operations.

(6.2.5 cont'd)

The Frequency Control & Analysis FMSS has a receive drop on the COMEDS, and extracts, analyzes and disseminates the following data to range and selected off-range Communications Electronics (CE) facilities:

- o Radio propagation reports and forecasts
- o Solar and geomagnetic disturbance reports
- o 2800 MHz solar radio flux reports
- o 1415 MHz solar radio flux reports
- o Immediate notification of solar disturbances affecting high frequency radio communications
- o Special reports extracted from satellite observation data, vertical incidence sounder data, etc.

6.3 RECORDS AND OPERATIONAL DOCUMENTAITON

The FMSS is responsible for maintaining frequency listings in microfiche form, JANAPS, ACP's, ITU, USAF, AFSC, WSMC, and CTSC originated documentation to support the research and analysis functions of the FCA System.

All frequency records, documents, and related data originated or collected, stored, and maintained in support of range frequency management are kept available for research and study. A communications storage unit using IBM compatible "floppy discs" is available in the FMSS for storage and recovery of radio frequency interference (RFI) and discrepancy information, as well as for use in reviewing past FCA major operational support functions. Interference data are available for the previous ten year period for the Western Test Range.

APPENDIX A

GLOSSARY OF ABBREVIATIONS

A	Ampere
ACP	Allied Communication Publication
AFC	Area Frequency Coordinator
AGC	Automatic Gain Control
ALCS	Airborne Launch Control System
AM	Amplitude Modulation
CE	Communications Electronics
CEM	Communications Electronics Meteorological
COMEDS	Continental Meteorological Data System
CT	Command Transmitter
CTSC	Center Technical Support Contractor
CW	Continuous Wave
dB	Decibel
dc	Direct Current
DoD	Department of Defense
ECAC	Electromagnetic Compatibility Analysis Center
EMI	Electromagnetic Interference
FAS	Frequency Assignment Subcommittee
FCA	Frequency Control and Analysis
FCAC	Frequency Control and Analysis Center
FCC	Federal Communications Commission
FM	Frequency Modulation
FMS	Frequency Monitoring Station
FMSS	Frequency Management Support Section
FSK	Frequency Shift Keying

GHz	Gigahertz
HF	High Frequency
Hz	Hertz
IF	Intermediate Frequency
IFRB	International Frequency Registration Board
in/min	Inch(s) per Minute
in/s	Inch(s) per Second
IRAR	Inter-Department Radio Advisory Committee
IRIG	Inter-Range Instrumentation Group
ITU	International Telecommunications Union
JFP	Joint Frequency Panel
kHz	Kilohertz
kV	Kilovolt
kVA	Kilovoltampere
kW	Kilowatt
LF	Low Frequency
mA	Milliampere
Max	Maximum
MCEB	Military Communication Electronics Board
MCW	Modulated Continuous Wave
MHz	Megahertz
min	Minute(s)
Min	Minimum
mm	millimeter

mm/s	Millimeter(s) per Second
mV/in	Millivolt(s) per Inch
NASA	National Aeronautical and Space Administration
NCC	Network Control Center
NOAA	National Oceanic and Atmospheric Administration
NTIA	National Telecommunications and Information Agency
OD	Operations Directive
OSTF	Operational Systems Test Facility
P	Pulsed Emissions
PAM	Pulse Amplitude Modulation
PCM	Pulse-Code Modulation
PDM	Pulse-Duration Modulation
PEP	Peak Envelope Power
PM	Phase Modulation
pps	Pulses per Second
RADHAZ	Radiation Hazard
RCO	Range Control Offficer
RF	Radio Frequency
RFA	Radio Frequency Authorizaton
RFI	Radio Frequency Interference
s	Second
SAC	Strategic Air Command
SCF	Satellite Control Facility
SFC	Solar Forecast Center
SFDS	WSMC Frequency Management Office
SHF	Super High Frequency

UHF	Ultra High Frequency
us	Microsecond
V	Volt
VAFB	Vandenberg Air Force Base
Vac	Volt(s) Alternating Current
Vdc	Volt(s) Direct Current
VHF	Very High Frequency
V/in	Volt(s) per Inch
VSWR	Voltage Standing Wave Ratio
VTS	Vandenberg Tracking Station
W	Watt
WAFC	Western Area Frequency Coordinator
WSMC	Western Space and Missile Center
WTR	Western Test Range

APPENDIX B

GLOSSARY OF TERMS AND DEFINITIONS

The following is a partial listing of terms commonly used in the frequency management community.

TERM	DEFINITION
APPARENT BANDWIDTH	The total visible signal observed on a spectrum display unit at a receiving/monitoring station, without respect to transmitter radiated bandwidth, power, or distance between transmitter and receiver locations.
ASSIGNED FREQUENCY	A specified frequency designated for use by an authorized agency.
BANDWIDTH	(1) The range of frequencies within which gain of an amplifier system remains above some certain fraction of its maximum value. (2) The range of frequencies below the low and high limits at which amplification or gain drops to a specified fraction of its maximum.
BEACON	(Transponder) Radio/radar transmitter receiver which transmits identifiable signals automatically when the proper interrogation is received.
BEACON DELAY	The fixed time delay between reception of an interrogation and the transmission of a reply to this interrogation.
BEACON DELAY VARIATION	The time difference of the beacon transponder reply pulse caused by changing levels of the interrogation signal.
BEACON, FREE RUNNING	Cyclic self-triggering of a beacon without being interrogated by an external source of RF energy.

BEACON INTERROGATION FREQUENCY — The frequency of maximum sensitivity, in megahertz, at which the beacon receiver is tuned.

BEACON POWER OUTPUT — The peak power of the beacon reply pulse, measured at the beacon output terminals and expressed in dBm.

BEACON RANGE DELAY — The difference in distance, expressed in microseconds, between the surveyed range and the actual radar range as measured at the interrogating source. Beacon range delay will be measured at the interrogate source and from the mean power distribution point of the reply pulse; the transmit time of a radar wave from the measuring device to the beacon antenna and back to the measuring device will then be subtracted.

BEACON TRANSPOND FREQUENCY — The frequency in megahertz, to which the beacon transmitter is tuned.

CLOSED LOOP — A circuit designed for instrumentation checks that will reduce any RF radiation to specified limits. For non-pulse beacons and transmitters operating below 1 GHz, the limit is 46 dBuV/M (RMS). For pulsed beacons and transmitters, the level has been established at 46 dBuV/m. These are measured at or corrected to a reference distance of 300 feet from the radiating source.

CLOSED LOOP CERTIFICATION — Authorization to conduct "closed loop" test after the system has been verified by an authorized agency. This certification does not preclude proper scheduling of frequencies used for tests.

CONTROLLED RADIATION — Frequency scheduling and control functions used to limit or silence specific radiating sources to afford protection to RF sensitive CE equipment.

COMMAND CONTROL — A system whereby functions are performed as the result of a transmitted signal.

DEVIATION — The instantaneous variation of frequency from the unmodulated or center frequency.

DEVIATION, DISTORTION	Distortion in an FM receiver caused by inadequate bandwidth, inadequate amplitude modulation rejection, or inadequate discriminator linearity.
DEVIATION, FREQUENCY	The peak difference between the instantaneous frequency of the modulated wave and the carrier frequency. The extent of deviation is proportional to the amplitude of the modulating signal. Normally expressed in degrees or radians. (One radian equaling 57.3 degrees.)
DISTORTION, DELAY	Distortion due to variation of the propagation time of the system with frequency.
FREQUENCY CLEARANCE	Permission granted to radiate (transmit) in support numbered or unnumbered range tests or operations.
FREQUENCY PROTECTION	Frequency scheduling and control functions which affords a range or range user's receiver freedom from radio frequency interference.
FREQUENCY SHIFT KEYING	That form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values, and the output wave is coherent with no phase discontinuity.
FREQUENCY SPECIFICATIONS	The technical parameters of authorized frequency usage specified with each frequency assignment, such as trans-mitter power, emission bandwidth, modulation, geographical limits, etc.
FREQUENCY SPECTRUM	Total range of wavelength of electro-magnetic radiations.
RADIO FREQUENCY	Includes the electromagnetic propagation spectrum from 10 kHz to 300 GHz.
RF SILENCE	Frequency scheduling and control functions used to silence all RF emitters on a specific frequency over a specified period of time. The term is used most frequently in association with electromagnetic and personnel RADHAZ requirements at the WSMC.

BIBLIOGRAPHY

AF Regulation 700-14, Radio Frequency Spectrum Management, Department of the Air Force, 1 November 1984.

AF Regulation 55-44, Performing Electronic Countermeasures in the U.S. and Canada, 6 December 1978.

WSMC Regulation 57-3, Range Resource Scheduling and Control Regulation, 2 April 1982.

WSMC Regulation 100-1, Radio Frequency Management, 22 August 1986.

WSMC Regulation 100-3, Closed Circuit Non-Radiating Checkout System, 30 June 1985.

WSMC Regulation 100-5, Intra-base VHF Radio Telephone Call Signs Assigned to WSMC Mobile Radio Networks, 6 December 1985.

WSMC Regulation 100-7, Instructions for Operations/Communications, Communications Security, and Frequency Management, 10 October 1986.

WSMC Regulation 127-1, Range Safety Requirements, 15 May 1985.

VAFB Regulation 700-18, Land Mobile Radio (LMR) System Management, 1 June 1987

VAFB Regulation 100-7, Amateur, Citizen's Band and Radiotelephone Operations, 7 June 1985.

VAFB Regulation 100-11, Closed Circuit Certification, 15 April 1987.

VAFB Regulation 700-14, Radio Frequency Management, 28 May 1987.

Inter-Range Instrumentation Group Document 106-86, Telemetry Standards, Revised, May 1986.

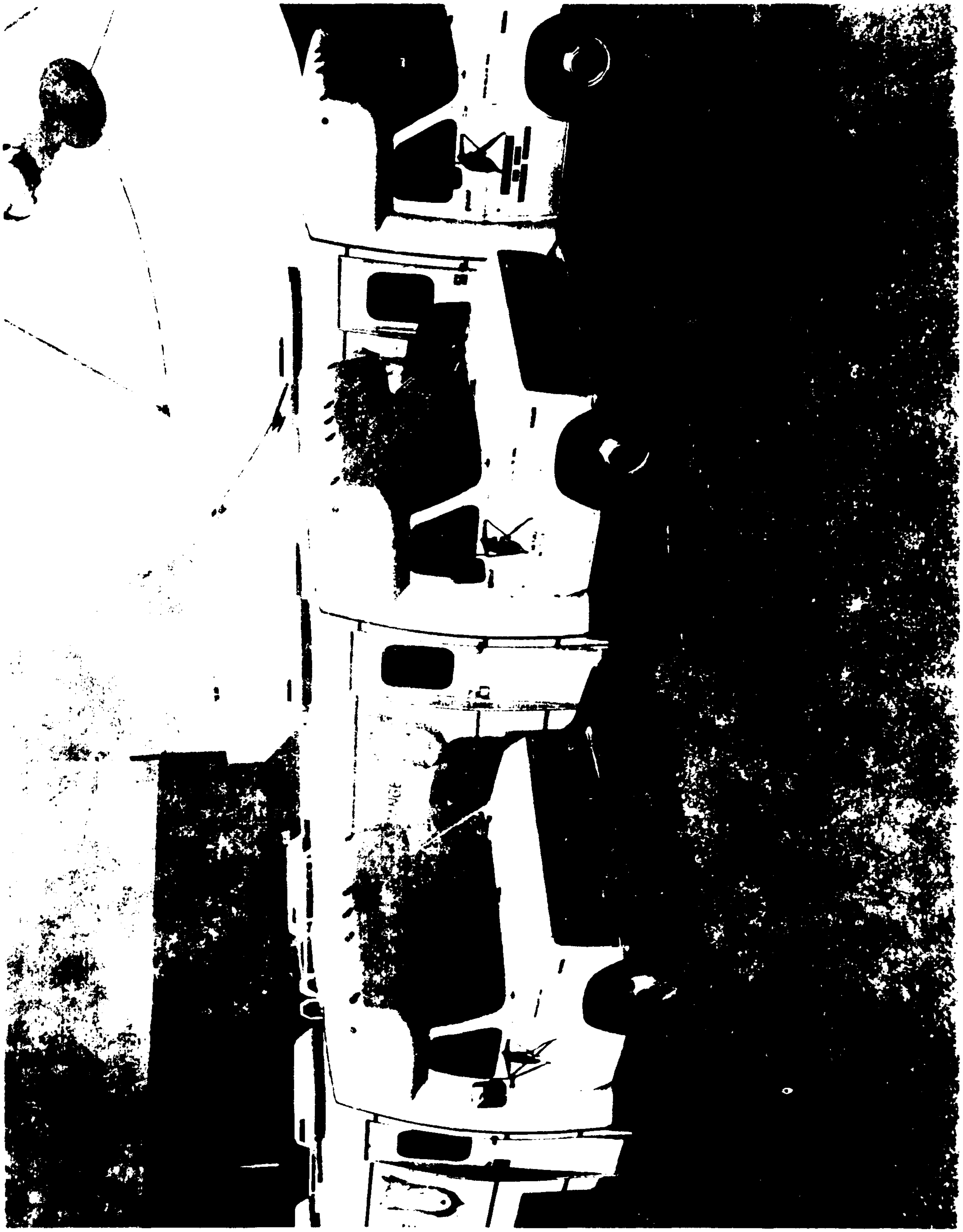
Range Safety Group Document 307-79, Range Safety Transmitting System, 406-549 MHz Band, Revised November 1979.

Rules and Regulations, Federal Communications Commission, Volume II, October 1982.

Handbook for CRPL Ionospheric Predictions Based on Numerical Methods of Mapping (Handbook 90), U.S. Department of Commerce, National Bureau of Standards, (.S., Ostrow), U.S. Government Printing Office, Washington, D.C., December 1962.

The Communications Act of 1934, (With Ammendments and Index Thereto), Federal Communications Commission, U.S., Government Printing Office, Washington, D.C.

Radio Regulations, International Telecommunications Union (ITU), General Secretariat of the ITU, Geneva, Switzerland.



WESTERN TEST RANGE
VANDENBERG AFB, CALIFORNIA

RADIO FREQUENCY MONITORING/MEASUREMENT FACILITIES

WTR
FREQUENCY CONTROL & ANALYSIS CENTER
(FCAC)

The WTR FCAC is the operational focal point for all WTR Frequency Control and Analysis (FCA) facilities and support functions. This unit: interfaces with range/range user agencies; responds to interference reports; schedules frequencies and forecasts potential conflicts; schedules and directs the field teams and mobile units.

WTR
RF MEASUREMENTS LAB
(RFML)

Performs diverse RF measurements for range and range user activities both in the field, and within a well equipped RF Measurements Lab. Tasks include range safety certifications, spectrum signature definition, RADHAZ measurement, closed loop certifications, range/range user calibration tests, RF problem analysis and EMI/RFI measurements.

WTR
FREQUENCY MONITORING STATION
(FMS)

The Frequency Monitoring Station includes a wide variety of RF receivers and supporting antenna systems covering the RF spectrum from 10 KHz to 25 GHz. Acting under the direction of the FCAC, the monitoring station: maintains surveillance of critical frequencies; monitors and measures range and range user transmitters; performs signal analysis and direction finding; makes a variety of audio and function recordings; participates in range/range user systems tests; logs and records critical portions of the RF spectrum during mission support periods.

WTR
FREQUENCY CONTROL AND ANALYSIS MOBILE UNITS

RF Measurements Van

Flexible unit for diverse/general RF field measurements and RF problem solving.

Transponder Test Van

Supports range safety and other range/range user test requirements to test, measure, analyze, document, troubleshoot, the operational characteristics of radar transponders.

Command Receiver Test Van

Supports range safety and other range/range user test requirements to test, measure, analyze, document, troubleshoot, the operational characteristics of range safety command receivers.

Range Safety Test Van

Developed and funded by range users who required precise pre-mission testing and certification of range safety systems aboard aircraft and missiles ... at locations remote from Vandenberg AFB.

WTR
AIRBORNE RF MEASUREMENTS

The RF Lab provides a wide variety of airborne RF measurements including antenna patterns and radar, telemetry and command receiver verifications. Lab equipment is installed in a twin-engine leased aircraft which operates out of Lompoc Airport; the measurement equipment is operated by flight certified RF Lab personnel.

APPENDIX I

WHITE SANDS MISSILE RANGE

WHITE SANDS, NEW MEXICO

DEPARTMENT OF THE ARMY
US ARMY WHITE SANDS MISSILE RANGE
White Sands Missile Range, New Mexico 88002-5032

WSMR Regulation
No. 105-11

28 June 1985

Communications - Electronics
RADIO FREQUENCY ALLOCATION, ASSIGNMENT, AND UTILIZATION

1. Purpose. To prescribe responsibilities, procedures, operational controls, and requirements for RF management and for RF users.

2. Scope. Applicable to: *a.* All Federal Government military elements, Federal Government nonmilitary elements, and employees and contractors thereof using RF transmitters, other RF-emitting equipment, or other equipment which is dependent upon the use of the RF spectrum at White Sands Missile Range (WSMR), WSMR-controlled real estate and test sites, and WSMR-based projects operating within CONUS areas.

b. WSMR personnel and organizations planning, developing, or processing the above defined equipment for use in the described areas.

c. WSMR projects conducting surface or inflight ECM in the State of New Mexico or other U.S. Territory within a 150-mile radius of WSMR, plus the areas of Utah and Colorado that lie south of 41° north latitude and between 106° and 111° west longitude.

3. References. See appendix A.

4. Explanation of Abbreviations and Terms. Abbreviations and special terms used in this regulation are explained in the glossary and are applicable to RF administration.

5. General. *a.* Effective radio frequency management is necessary to achieve the maximum-efficient usage of the limited electromagnetic RF spectrum.

b. EMC analysis (including the control of RF interference) extends from the inception of ideas through investigation or discovery of research potentials; creation and testing of new or improved theories, techniques, processes, materials, or items; and evaluation and final acceptance (procurement) or rejection of C-E materiel for use. Research and development cycles required to produce new improved C-E materiel will stress EMC to preclude costly fixes or retrofit (improvement) programs in production items (also see 7*e* below).

c. Conditions and procedures have been directed or established to ensure that adequate RF provisions will be available for C-E equipment prior to experimentation, development, production, service testing, procurement through military services, or the direct procurement (off-the-shelf) from commercial suppliers.

d. Radio Frequency information contained

*This regulation supersedes WSMRR 105-11, 21 September 1979.

in UDS publications is used by the Operations Division, US Army Information Systems Command (USAISC)-White Sands for providing guidance and advice to the project engineers and for planning the RF support which will be provided to the WSMR-accepted projects. Notification of program acceptance and supportability statements by WSMR for UDS does not constitute an RFA, i.e., statements of needed radio frequencies or radio frequency bands in the UDS are not considered formal requests for radio frequency allocation or radio frequency assignment; separate actions are required (see 9*a* and *b* below).

e. In addition to the requirements and procedures stated herein, other specific guidance/direction for the use of C-E equipment at WSMR is established in WSMRR 105-2 and WSMRR 105-10. Mandatory requirements for controlling personnel hazards from RF devices are contained in WSMRR 40-9.

6. Objectives. The primary objective of RF management is to satisfy all RF requirements through optimum utilization of the RF spectrum. Subobjectives are:

a. To realize effective use of the limited RF spectrum assets by the apportionment of available radio frequencies or spectrum space among the different requirements and competing demands.

b. To ensure that all C-E equipment users, sharing the same environment and RF spectrum, work closely together in order to resolve mutual problems arising from the dependence of all users on RF spectrum support from the one common resource.

c. To furnish technical guidance to research, developmental, and testing activities and to make provisions in long-range planning for future uses of the RF spectrum.

d. To promote active participation and intelligent RF spectrum planning, utilization, and control among designers, manufacturers, testers, and users.

7. Policies. *a. Radio frequency management.* The task of the Operations Division (USAISC-White Sands) (ASNC-TWS-O) is to serve the objectives of the Federal Government and DOD through careful administration of WSMR's RF utilization plans and equipment capabilities. This division must be responsive to the entire RF needs of WSMR, while at the same time taking into account due limitations, as well as the right of other users of the RF spectrum.

b. RF allocation and RF assignment.

(1) C-E equipment, the operation of which is dependent upon the use of the electromagnetic spectrum on radio frequencies below 3,000 GHz, requires both an RF allocation and an RF assignment. Equipment, except as stated in paragraphs (*b*) and (*j*), below, for which an RF allocation has not been granted or for which an appropriate waiver has not been issued, will not be authorized RF assignments.

(a) DA funds will not be released to the contracting officer for the development, purchase, lease, or use of C-E equipment which is dependent upon the use of the RF spectrum, until WSMR has been formally advised by DA that a DD Form 1494 (Application for Frequency Allocation) for the equipment has been received and that the equipment has been deemed suitable by the JFP for frequency allocation support. Prior to any contractual obligation for the procurement or development of any site which is intended for use as a C-E facility or one which will require radio communications, assurances that RF assignment support is available must also be obtained. Similar funds release restrictions/policies exist in Air Force and Navy regulations.

(b) As an exception to (a), above, C-E equipment to be used in support of WSMR activities do not require a formal JFP radio frequency allocation approval if its use will be confined to the WSMR geographical area of cognizance; however, the DD Form 1494 will require an approval (statement that the proposed equipment is supportable with radio frequency assignments) by the DOD AFC, WSMR, prior to the release of DA funds. (As used herein, the "WSMR geographical area of cognizance" applies to (1) on-range projects under the cognizance of the Commander, WSMR, (2) off-range Army activities, which relate to DOD range projects, operating within the area of responsibility of the DOD AFC, WSMR, and (3) Fort Bliss and its ranges, but only if the equipment or project involved is under the cognizance or sponsorship of the Commander, WSMR. This stated exception does not apply to C-E equipment intended to be deployed at WSMR as one of several test sites to be located elsewhere.)

(c) Procurements of industrial, scientific, medical equipment, and ultrasonic equipment as defined in AR 5-12, paragraph 4-6, are exempt from all requirements of (a) and (b), above. Incidental radiation devices and items of material used solely to activate a fuse or detonator are also exempt if the operating agency has agreed to eliminate any harmful interference which may be caused to an authorized radio service.

(d) Electronic countermeasures equipment is exempted from the formal RF allocation approval process; however, a completed DD Form 1494 must be submitted through command channels per AR 5-12, paragraph 4-3b(2).

(e) Receivers and antennas developed independently of transmitting equipment do not require an RF allocation; however, a completed DD Form 1494 submission is required before undertaking each of the various phases of the development and procurement cycle.

(f) Base nontactical radios are exempted from the formal RF allocation approval process provided (1) the equipment does not have an assigned military nomenclature; (2) the equipment will be operated within the United States and its possessions within a 25 kHz channel in the 138-150.8, 162-174, or 406.1-420 MHz bands; (3) the transmitter output power to the antenna is not more than 100 watts; (4) the equipment is FCC type accepted; and (5) the DOD AFC certifies that sufficient radio frequency assignments are available. (DOD AFC certification will be solicited by following those procedures described in paragraph 9a(2) below).

(g) Lasers used for telecommunication and nontelecommunication purposes must be registered (in addition to requirements in WSMRR 385-15) before actual employment.

(2) All transmitting devices having an EIRP of greater than 3.16 microwatts (-25 dBmW) on their fundamental frequency are required to have an RFA.

(3) Requests for RF radiation on either a scheduled basis or nonscheduled basis will be approved only for those users having a valid/current RFA (see glossary for definitions).

(4) Equipment for which conceptual experimental research (experimental), exploratory development (developmental) RF allocations, or RF assignments have been obtained will not be afforded protection from operations of other equipment for which advanced or engineering development (limited operational) or operational RF allocation or RF assignments have been authorized.

(5) LPD's such as cordless telephones and wireless microphones operate at various frequencies within the spectrum bands used by military activities. Part 15 of FCC rules and regulations, supported by DA, states that users of LPD's "must accept any interference which may be caused by the operation of any licensed station." Frequency protection, therefore, is not afforded LPD's nor is any consideration given the devices by frequency management personnel selecting specific frequencies for use in support of military communications requirements. Conversely, the operation of LPD's must cease if they cause RFI to licensed stations.

(6) Permission to operate CB and amateur equipment will generally be given; however, operations in the 220-225, 420-450, 1215-1300, 5650-5925, and 10,000-10,500 MHz bands may be severely restricted.

(a) Except for an emergency (see glossary for definitions), neither amateur nor CB equipment will be authorized for use in support of any WSMR project or operation. Said equipment will not be utilized for or considered as an extension or backup to any Army communication system. Additionally, users of said equipment are prohibited from divulging (including retransmitting) or using information derived by intercepting police radio messages not directed to them or not intended for the general public.

(b) Amateur equipment operating in the 420-450MHz band at WSMR or in the surrounding areas will be additionally governed by Footnote US 7 to the U.S. Allocation Tables; equipment operators will comply with this footnote. Amateur equipment operating in the 220-225 MHz band is subject to the prohibition of causing harmful interference to radio location services.

(c) Personnel (resident and nonresident), after receipt of an FCC amateur license (FCC CB licenses are no longer issued), will obtain an ROP from ASNC-TWS-O before making any transmissions at WSMR or in WSMR off-range areas. (Refer to 9c below for procedures for obtaining an ROP.)

(*d*) Resident personnel will coordinate with and obtain the approval of the WSMR Directorate for Installation Support (STEWS-IS) before erecting any station antennas in the WSMR housing area.

(*e*) Limited operation of a military CB radio station may be authorized as described in AR 105-4, paragraph 6. (Operations will be limited to one station in a given area and be operated under the direction of the WSMR Commander. Normally, the CB station will be authorized to operate on CB radio channel 9 (emergency channel) and one additional channel.)

c. Control of radio emissions from spacecraft. (See glossary for definition.) RF usage in spacecraft will be such that a positive control exists whereby radio emissions therefrom can be discontinued when required. Battery life, barometric switches, etc., are not considered positive; a command-off control or manual switch-off capability is required.

d. Use of the term "hertz." (This is a unit of radio frequency which is equivalent to one cycle per second.)

(*1*) Hertz will be the only appropriate term for the unit of frequency to be used in referencing radio frequencies or bands of C-E equipment in all correspondence, records, standards, purchase descriptions, procedures, other documents, and where applicable, on equipment.

(*2*) Approved terms, abbreviations, and their equivalents are:

Term and Abbreviation		Equivalent to Cycles per Second
Hertz	Hz	10^{0}
Kilohertz	kHz	10^{3}
Megahertz	MHz	10^{6}
Gigahertz	GHz	10^{9}
Terahertz	THz	10^{12}

(*3*) Radio frequencies will be expressed in kHz below 30,000 kHz, in MHz from 30 MHz to (but not including) 100,000 MHz; in GHz from 100 GHz to (but not including) 3,000 GHz, and in THz at 3 THz and above.

(*4*) RF band letter designations (e.g., P, L, S, C, X, K, Q, and V) are a source of confusion and ambiguity; they will not be used in official documents or correspondence. Actions will be taken to eliminate these band letter designations in new or revised publications.

e. EMI control requirements.

(*1*) Standards covering the emission and susceptibility requirements and test limits for electronic, electrical, and electromechanical equipment, subsystems, and systems are specified in MIL-STD 461; this standard will be used in conjunction with MIL-STD 188C, 454J, 462, 463A, and 469. Adherence to these standards and specifications by C-E materiel development, procurement, and leasing agencies is mandatory unless specifically waived by Headquarters U.S. Army, Navy, or Air Force, as appropriate.

(*2*) Telemetry transmitters, telemetry receivers, and closed circuit telemetry systems must possess and demonstrate RF parameters that meet the requirements outlined in WSMRR 105-10.

(*3*) Electromagnetic compatibility, RFI, EMI, or spectrum utilization characteristics/information of all transmitting/receiving C-E equipment used at WSMR will be provided to ASNC-TWS-O upon request. If the requested information is not available, the subject equipment will be made available for test, analysis, and collection of required data. Testing of equipment capable of emitting potentially hazardous levels of RF/microwave radiation will be coordinated with the WSMR RPO.

f. Electromagnetic countermeasures operations. These operations will not be suspended or curtailed by ASNC-TWS-O unless such action is absolutely unavoidable as in the case of an emergency safety or flight situation or negation of the operational use of a facility. The DOD AFC will resolve those non-WSMR ECM-related frequency coordination conflicts which transcend the operational scope of ASNC-TWS-O.

g. Radio frequency transmitting equipment. This equipment will not be used for purposes or services other than those identified in the initial (or modified) justifications for RF assignments or specified in subsequent RFA's. RF assignments are not transferrable from one RF user to another; organizations having requirements to use transferred or borrowed RF transmitting equipment shall be responsible for obtaining their own RF assignments and failure to do so will be considered a violation of this regulation.

h. Violations. Violators of the requirements of this regulation, when an RFA or the conditions of RF assignment have been disregarded, or when transmitting systems are operated without an RFA, will receive a formal written notification. Notifications will be sent by WSMR's Director of Information Management (STEWS-IM) to the chiefs of WSMR organizations, satellite activities, or applicable WSMR range sponsors. Addressees will initiate corrective action and reply by endorsement within 10 workdays after receipt of notification. Operations of CB, amateur, and other FCC-licensed equipment will be suspended for 30 days for the first offense; a second offense will result in a permanent suspension of operations at WSMR.

8. Responsibilities. *a.* Chief, ASNC-TWS-O will:

(*1*) Control the use of all RF's used at WSMR, all RF's used off range by WSMR-based projects operating on or over WSMR-leased or -owned real estate, and all other RF's (regardless of geographical area usage) which are assigned to WSMR.

(*2*) Coordinate all WSMR actions pertaining to RF coordination, management, allocation, and assignment. Formulate and enforce regulations and directives to accomplish assigned missions.

(*3*) Ensure optimum spectrum utilization and promote methods and techniques to minimize RF interference potentials.

(*4*) Ensure proper and legal RF usage.

(*5*) Provide RF control, analysis, and surveillance services in technical support of WSMR, the DOD AFC, other Federal Government agencies, and the Frequency Management Group, Range Commanders Council.

(*6*) Operationally coordinate and control ECM activities for the DOD AFC who executes the interservice frequency coordination responsibilities as directed by the MCEB of the Joint Chiefs of Staff.

b. All organizations operating in the referenced area and having overall responsibility for the coordination of Federal Government projects/operations will:

(*1*) Secure an RF allocation and an RF assignment.

(*2*) Schedule or obtain the required clearance for the use of all restricted RF's associated with their projects/operations (see 9*d* below.)

(*3*) Initiate formal requests for keeping their RF allocations and RF assignments accurate and current.

(*4*) Provide ASNC-TWS-O with a copy of the site coordination letter or site usage/occupancy permit if requesting RF assignments for transmitters which will be located in areas not controlled by WSMR. Site use permit or coordination letter will be obtained through STEWS-IS per WSMRR 405-1.

(*5*) Discontinue operations until necessary measures have been taken to eliminate RFI if possessing and using RF radiating devices as described in 7*b*(*1*)(*c*), above, which cause RFI even though said devices meet the radiation requirements.

(*6*) Provide ASNC-TWS-O with specific susceptibility criteria to substantiate their recommended RF silences or avoidances. Silence and avoidance requirements will then be validated, coordinated, and effected by ASNC-TWS-O.

(*7*) Immediately report all MIJI (see glossary for definitions) incidents directly to the SCO, ASNC-TWS-C.

(*8*) Comply with AR 40-583, WSMRR 40-9, and WSMRR 385-15, before radiating potentially hazardous levels of RF radiation.

c. Purchasing and contracting officers are responsible for ensuring FAR paragraph 52.235-7004 is complied with in all contracts involving electromagnetic radiating devices. These FAR provisions specify that DD Form 1494 must be furnished to the contracting officer for any experimental, development, or operations equipment for which an RF allocation is required (reference AR 5-12, para. 4-2d).

d. All persons and organizations desiring to operate CB, amateur, and other FCC-licensed transmitters on WSMR will secure an ROP from ASNC-TWS-O. (See 7*b*(*6*), above).

9. Procedures. *a.* RF allocations. (See 7*b*, above).

(*1*) *General.*

(*a*) RF allocations fall into four stages which support each distinct phase of the LCMM.

1. Stage 1 (conceptual) allocation is required before releasing funds for studies or assembling "proof-of-concept" test beds.

2. Stage 2 (experimental research or exploratory development) allocation is required before the award of a research or

exploratory development contract or the initiation of in-house research and development.

3. [illegible] advanced or engineering development allocation is required before the award [illegible] engineering development contract.

4. [illegible] allocation [illegible] the award of an [illegible] contract.

[illegible] Form 1494 submission is required [illegible] the various phases of the procurement cycle or the initiation of [illegible] fabrication of hardware. Procurement, [illegible] defined as acquisition from any source, e.g., [illegible] contract for production, direct from other military services [illegible] commercial suppliers (off-the-shelf), and [illegible] actions.

[illegible] The [illegible] elements will submit [illegible] Form 1494 [illegible] for review, coordination, preparation [illegible] and forwarding [illegible] ASNC-TWS-[illegible], will provide [illegible] finalized/forwarded form to the requesting element and one copy [illegible].

[illegible] The [illegible] non-TECOM elements [illegible] their [illegible] Form 1494 through [illegible] TECOM and [illegible] by [illegible] ASNC-TWS-[illegible] and the [illegible].

[illegible] A elements [illegible] Forms 1494 [illegible] their [illegible] service [illegible] lives.

[illegible] The [illegible] processing time for a [illegible] Form 1494 [illegible] requires [illegible] days. [illegible] exceptional circumstances exist [illegible] contractual action [illegible] release of funds [illegible] requested [illegible] allocation [illegible] requests will [illegible] indicated on the [illegible] Form 1494 along with a full justification. The justification must show that waiting the normal processing time would clearly not be in the interests of the Government.

[illegible]

[illegible] The [illegible] TECOM and non-TECOM elements, [illegible] proposed [illegible] systems will [illegible] activities and the [illegible] will be contained [illegible] geographical area of cognizance (see 7b(1)(b) above for area description), will submit one copy of [illegible] Form 1494 to ASNC-TWS-C for review, coordination, preparation of final copies, and forwarding to the [illegible]. Chief, ASNC-TWS-C, will provide one copy of the finalized forwarded [illegible] the requesting element.

(5) Equipment approved [illegible] for use in support of range activities does not require a formal RF allocation approval; however, this approval provides no assurance that an RF allocation can or will be subsequently approved [illegible] for the equipment's use in other geographical areas, should new requirements later arise.

(3) Upon formal notification of RF allocation action taken by the [illegible] of the [illegible] approval of the [illegible] to be [illegible] equipments (see 9a 2 [illegible]), ASNC-TWS-C will provide subsequent documentation to the requesting [illegible] elements. Subsequent to the receipt of the initial RF allocation authorization, all necessary changes in the parameters of the submitted allocation request will [illegible] promptly [illegible] to ASNC-TWS-[illegible] for [illegible] actions.

[illegible] RF assignments.

(1) New assignments and [illegible] existing assignments. [illegible] application for the addition, substitution, or removal of one or more of the particulars, other than the [illegible] of an existing RF assignment.

(a) The [illegible] TECOM and non-[illegible] elements will submit [illegible] the appendix [illegible] to ASNC-TWS-[illegible] for review, coordination, [illegible] forwarding [illegible].

(b) For RF's [illegible] MHz, the [illegible] will be submitted to ASNC-TWS-[illegible] days before the proposed [illegible] date, for RF's below [illegible] MHz, [illegible] time will be required.

[illegible] ASNC-TWS-[illegible] will provide one copy of the finalized forwarded [illegible] the requesting element.

(2) Renewals and Deletions of existing assignments. The [illegible] TECOM and non-TECOM element RFA assignees are responsible for keeping their RF assignments current and submitting written requests to ASNC-TWS-[illegible] for renewal or deletion actions.

(a) Renewal requests for extending an existing RFA beyond its expiration date will be submitted to ASNC-TWS-C in the same time frame as 9b(1)(b), above. Specifically, the requests will.

1. Identify the additional period required.

2. Certify that no changes have been made [illegible] characteristics, [illegible] use, [illegible].

3. [illegible] justification for [illegible] use.

[illegible] for cancel[illegible] existing [illegible] will be submitted to [illegible] within [illegible] following a [illegible] that the [illegible] longer required.

[illegible] SFAF will [illegible] forward [illegible] information [illegible] the [illegible] status is [illegible] equipment to be [illegible] activities and within the [illegible] area of [illegible] with a [illegible] SFAF will [illegible] operations [illegible] unless a copy [illegible] site [illegible] provided.

[illegible] ASNC-TWS-O will [illegible] assignee; [illegible] also [illegible] from the [illegible] transmitter [illegible] would exist [illegible] of the [illegible] be provided [illegible] WSMR [illegible] (STEWS-[illegible]-SE); and the [illegible] (STEWS-[illegible]), for [illegible] safety, radiation [illegible] engineering aspects, respectively.

[illegible]

[illegible] or [illegible] desiring [illegible] at WSMR [illegible] will submit a [illegible] disposition [illegible] Permit [illegible] 10 work days [illegible] date.

(2) Following the receipt of request, [illegible], ASNC-TWS-[illegible] an RDP (CCNC Form [illegible] and [illegible] the requester.

3 [illegible] in the immediate [illegible] the operator of subject [illegible] when the station [illegible] or in WSMR off-[illegible].

f. *RF scheduling.*

[illegible] in Appendix B, [illegible]. All [illegible] bands will require the scheduling of specific RF's and radiation times with the RSC or obtaining permission from the ASNC-TWS-O SCO for operation on a nonscheduled basis.

(2) Requirements for authorized RF's to be used on a nonscheduled basis will be telephoned to the SCO; if requirements can be accommodated and do not conflict with the official range schedule which takes precedence, the requester will be provided with an authorization number and other necessary operational restraints. Requesters will also notify the SCO if their radiation requirements terminate before the end of their approved time block.

(3) RF users will employ closed-circuit systems for equipment checkouts wherever practicable.

g. MIJI Reporting - RCS: JCS 1066 (U)... (See glossary for definitions.)

(1) Any WSMR user of C-E materiel who experiences MIJI will:

(a) Immediately report all details of the incident directly to the SCO. This direct reporting requirement does not preclude subsequent user reporting to other range elements which may be deemed necessary.

(b) Categorize the MIJI and specify if it is suspected as being hostile in origin.

(c) Provide additional/specific details as may be required by the SCO to satisfy formal MIJI reporting requirements.

(d) Notify the SCO when the MIJI ceases.

(2) Upon receipt of a MIJI report, Chief, ASNC-TWS-O, will:

(a) Immediately use all [illegible] operational [illegible] in a concentrated effort to identify and locate the MIJI source. [illegible] activities relating to the resolution [illegible] actual WSMR or non-WSMR MIJI involving the safety of personnel or operations will take precedence over all other [illegible] work assignments/ activities including [illegible] support.

(b) Evaluate the possibility of locally generated spurious signals and other technical difficulties which might have caused the incident. Evaluations will include an analysis of C-E systems collocated with the victim system and those in contiguous areas.

(c) Keep the MIJI reporters (victims) advised of all actions taken to resolve the MIJI problem.

d. Consolidate all pertinent data/ information obtained into a formal MIJI report per AR 105-3. The MIJI reporter (victim) will be provided with a copy of the formal MIJI report (ASNC Form 581).

(3) All MIJI incidents wherein the MIJI was suspected as being hostile, if the interference source was not readily identified, and those representing an electromagnetic [illegible] problem, will be forwarded by ASNC-TWS-O to the DOD AFC for subsequent action, [illegible], and dissemination. Similarly, all MIJI incidents which involve a DA element and another military service, or were between any military service and a Government nonmilitary or nongovernment organization, will also be forwarded to the DOD AFC for information or action.

(4) All MIJI reports, which involve RF users at WSMR or in WSMR-controlled areas who have violated their RF authorizations, will be prepared by ASNC-TWS-O and forwarded by [illegible] to the chief of the violator's organization for corrective action. (See 7h above.)

[illegible] Radar tracking or illumination of targets of opportunity. Projects and organizations desiring to radar-track or illuminate objects not fully described in the WSMR [illegible], for a test operation other than their own, will obtain written permission from the prime project conducting the operation, i.e., statements of the desire to track or illuminate targets of opportunity in the [illegible] do not constitute a permission. A [illegible] written permission [illegible] [illegible] forwarded to ASNC-TWS-O [illegible] radiation permission.

[illegible]

[illegible] procedures for obtaining [illegible] frequency authorizations in local restricted frequency clearance are specified in AR [illegible]. All authorized [illegible] frequencies will be scheduled per 9b above, prior to their use.

(2) The dispensing of metallic rope chaff will require that ASNC-TWS-O be provided a copy of the special authorization issued from the pertinent major command headquarters. Additionally, the dispensing of metallic rope which is equal to, or greater than, 0.5 meters in length will require the range user to formally assume full responsibility for all damage and costs that may be incurred as a result of metallic rope chaff drops.

(3) Chief, ASNC-TWS-O, will:

(a) Accept and control, in behalf of the DOD AFC, authorized small- and large-scale [illegible] operations in the area. (See para 2.

(b) Notify the DOD AFC or the ECM user if conflicts are expected or exist with critical WSMR operations.

(c) Issue an ECM "STOP BUZZER" if actual interference is experienced from the ECM operation; this DOD AFC delegated responsibility will be judiciously applied.

(d) Perform other ECM notifications/coordinations as may be required.

h. Laser registration.

(1) *Telecommunication lasers.* Registration will be accomplished in a manner similar to that used for obtaining an RF assignment, i.e., submission of [illegible] per 9b, above.

(2) *Nontelecommunication lasers.* The following information will be forwarded to ASNC-TWS-O for subsequent forwarding through the DOD AFC to the IRAC:

(a) Operating agency

(b) Date of planned activation

(c) Frequency or frequency band of operation in THz

(d) Output power: PEAK for pulsed emissions; MEAN for continuous emission, in kilowatts, megawatts, or gigawatts, as appropriate.

(e) Emission and bandwidth: Indicate whether radiation is pulsed or continuous. Indicate nominal radiated bandwidth in megahertz below 1,000 MHz and in gigahertz at 1 GHz and above.

(f) Location: Indicate name of place and geographical coordinates for specific locations or define area of use by [illegible] names of places [illegible] geographic coordinates, if appropriate.

(g) Direction of radiation: Indicate the horizontal azimuth of the beam in degrees from true north, where feasible. If direction of radiation is variable and unpredictable, so state.

(h) Function: Give brief indication of function and purpose.

(i) Remarks: Provide any additional information deemed useful in evaluating interference potential from the notified use to telecommunication laser operations.

i. Purchase description and supporting documents. (See WSMRR 702-4 and WSMRR 40-9.)

(1) Developers of purchase descriptions for C-E materiel will ensure that adequate EMC/EMI control requirements are fully identified/documented therein. (See para 5b, 7e(1), and 7e(2) above.)

(2) In completing para 54 of Checklist for Purchase Descriptions and Supporting Documents (EWS Form 1052, Part I), the Chief, ASNC-TWS-O, will consider the full requirements of AR 5-12.

(*a*) If the item to be procured is one that requires a formal JFP RF allocation, ASNC-TWS-0 will:

1. Concur and enter the appropriate J/F number and date of the approval action (e.g., J/F 12/2617/1, 8 Nov 85) in paragraph 6, Remarks, if the item has a valid RF allocation authorization.

2. Concur and identify the Release of Funds Concurrence document in paragraph 6, if the item does not yet have an RF allocation authorization but a DD Form 1494 has been submitted and a Release of Funds Concurrence has been issued.

3. Nonconcur and add the following in paragraph 6: "Note: Radio frequency allocation (or a Release of Funds Concurrence) request was submitted on (date); however, a reply has not yet been received. Upon receipt of appropriate reply, this nonconcurrence may be cancelled and funds may then be released." If the item does not yet have an RF allocation authorization and a Release of Funds Concurrence has been requested but not received. (DD Form 1494 submission and subsequent approval (RF allocation) or supportability statement are required before obligation of funds.)

4. Nonconcur and enter the reason in paragraph 6, if an RF allocation or a Release of Funds Concurrence has not been requested.

(*b*) If the item to be procured is one that is excepted from the requirements for a formal RF allocation, but for which a completed DD Form 1494 submission and a DOD AFC frequency supportability statement are required, ASNC-TWS-0 will enter: "Concur. DD Form 1494 and frequency supportability statement on file." or "Nonconcur. DD Form 1494 or request for frequency supportability statement not submitted/approved." (See para 7b(1)(b), (d), and (4).)

(*c*) If the item to be procured is one that does not require a formal JFP RF allocation, ASNC-TWS-0 will enter: "Concur: J/F 12 actions do not apply" in paragraph 6. (See paragraph 7b(1)(c)).

(*d*) If it is not known whether an item to be procured has an RF allocation authorization and the purchase description is structured so as to require bidders to identify the RF allocation authorization or submit a completed DD Form 1494 for each proposed item, ASNC-TWS-0 will enter, "Nonconcur. This nonconcurrence may be cancelled and funds obligated upon receipt of the RF allocation authorization information or upon receipt and a favorable response to the subsequent processing of completed DD Form 1494."

j. *Radio procedures and call signs.*

(*1*) RFA, among other things, specify the assigned call signs and unit call signs for communications nets. Unless specifically provided, local derivation of other call signs and use is prohibited.

(*2*) RFA assignees are responsible for:

(*a*) Ensuring proper call sign usage.

(*b*) Designating NCS.

(*c*) Prominently displaying RFA at the base transmitter and NCS of nontactical radio nets.

(*d*) Issuing/implementing an SOP for net operations. Specifically, an SOP is mandatory for fire, security guard, military police, transportation (taxi), motor pool, and CB radio net operations. (See DARCOMR 105-11).

(*3*) The NCS, usually the station serving the highest Headquarters within a net, has the responsibility for maintaining communications discipline within the net and exercising operational control over the net. The NCS is responsible for:

(*a*) Opening and closing the net, controlling transmissions and clearing net traffic, and maintaining DA Form 3945 (Military Police Radio Log) or an equivalent record of net operations.

(*b*) Transmitting the assigned call sign at the beginning and end of operation and at least hourly, preferably within 10 minutes before to 10 minutes after the hour, as long as the net identification does not interfere with existing net traffic.

1. Radiotelephony identification will be made by speaking the proword (procedure word) "THIS IS" followed by the assigned call sign.

2. Radiotelegraphy identification will be made by sending, in international morse code, the prosign "DE" followed by the assigned call sign.

3. Radioteletype transmissions will be identified by transmitting the prosign "DE" followed by the assigned call sign in teletype characters.

(*4*) Radio nets will not be used as a routine substitute for communications already provided by intercoms or telephones.

(5) The following net practices are specifically forbidden:

(a) Discussion of classified information, except on secure nets.

(b) Violation of a radio silence when imposed by the NCS.

(c) Unofficial conversation between operators.

(d) Excessive tuning and testing.

(e) Transmitting the operator's personal sign or name.

(f) Use of other than authorized prowords and unauthorized use of plain language in place of applicable prowords or operating signals.

(g) Profane, indecent, or obscene language.

(6) Some of the more commonly used/authorized prowords are listed in appendix C. (Prowords are pronounceable words or phrases which have been assigned meanings for the purpose of expediting message handling; prowords (or combinations) will not be used in the textual component of a message.) Additional authorized prowords are listed in ACP 125.

(7) The authorized phonetic alphabet and the accepted pronunciation of numerals are listed in appendix D.

(8) Per DARCOMR 105-11, APCO 10 Signals (appendix E) will be used for intra-AMC station communications and for applicable/authorized communications with Federal, State, and local civil public safety officials who have adopted the APCO "10 Signals."

(9) If specific call signs have not been formally assigned to a radio net, P.I must be used; this consists of the word "ARMY," the geographical location of the station or operation, and the type of operation, e.g., "ARMY, WHITE SANDS MISSILE RANGE, RADAR VOICE NET."

(STEWS-IM/ASNC-TWS-O)

b. *Encryption of RF Signals.* Certain/unique situations or programs may require the RF transmission of classified defense information such as telephony/voice, telemetry, etc. To safeguard these types of radio signals from compromise, encryption (the conversion of plain text messages into disguised/secure forms by means of an approved cryptosystem) may be required.

(1) All plans relative to the development, application, or implementation of an encryption system will be submitted to the WSMR Signal Security (SIGSEC) Board for review and approval per WSMRR 380-5.

(2) Users of encryption devices on RF transmitters are additionally responsible for ensuring that their encryption methods are sufficiently covered in the authorized emissions stated on their RF authorization, i.e., authorized emissions are limited to the necessary bandwidth, type of modulation, and type of transmission authorized, e.g.:

(a) 16F3E emission designator only permits a 16 kHz necessary bandwidth, frequency modulation, and the transmission of telephony/voice; this designator (16F3E) would not permit encryption, even if the necessary bandwidth and the type of modulation remain unchanged, because the type of transmission would necessarily be different. In this example, a 16F1E emission designator would have to be authorized to legalize encrypted transmissions.

(b) Similarly, and in the case of telemetering, a 600KF1D8W emission designator would only permit a 600 kHz necessary bandwidth, frequency modulation, and the transmission of composite elements; this designator would not permit encrypted telemetry if the encryption resulted in a necessary bandwidth in excess of 600 kHz or if the resulting type of modulation was other than frequency.

FOR THE COMMANDER:

OFFICIAL:

Robert Sheets Jr

ROBERT SHEETS, JR.
Captain, AGC
Adjutant General

VERNON E. EBERT
Colonel, GS
Chief of Staff

DISTRIBUTION:

A;E;M
A[illegible]-AS[illegible]
A[illegible]-AS-AM(3)
ASNC-TWS-[illegible]

Cdr, TECOM, ATTN: AMSTE-SG-A(1)
Cdr, USAIS[illegible]-AM[illegible] 1[illegible]

Appendix A

References

Section I

Required Publications

AR 5-12	(Army Management of the Electromagnetic Spectrum). Cited in paragraphs 7b(1)(c) and (d).
AR 40-583	(Control of Potential Hazards to Health From Microwave and Radio Frequency Radiation). Cited in paragraph 8b(8).
AR 105-3	(Reporting Meaconing, Intrusion, Jamming, and Interference of Electromagnetic Systems). Cited in paragraph 9e(2)(d).
AR 105-4	(Operation of CB Radio Equipment). Cited in paragraph 7b(6)(e).
AR 105-86	(Performing Electronic Countermeasures in the U.S. and Canada). Cited in paragraph 9c.
MIL-STD 188C, Notice II	(Subsystem Design/Engineering and Equipment Technical Design Standards for Long Haul Line of Site Digital Microwave Radio Transmission). Cited in paragraph 7e(1).
MIL-STD 454C	(General Requirements for Electronic Equipment). Cited in paragraph 7e(1).
MIL-STD 461	(Electromagnetic Requirements for Control of Interference). Cited in paragraph 7e(1).
MIL-STD 462	(Electromagnetic Interference Characteristics). Cited in paragraph 7e(1).
MIL-STD 463A	(Definitions and System of Units, Electromagnetic Interference and Electromagnetic Compatibility Technology). Cited in paragraph 7e(1).
MIL-STD 469	(Radar Engineering Design Requirements Electromagnetic Compatibility). Cited in paragraph 7e(1).
DARCOMR 105-11	(Nontactical Fixed/Mobile Radio operations and Maintenance). Cited in paragraph 9j(2)(d), 9j(8).
WSMRR 40-9	(Control of Potential Hazards to Health From Nonionizing Radiation). Cited in paragraphs 5e, 8b(8), 9i.
WSMRR 105-2	(Potential Interference to Frequency Surveillance and Analysis Facilities). Cited in paragraph 5e.
WSMRR 105-10	(Telemetry Radio Frequency (RF) Spectrum Utilization). Cited in paragraphs 5e, 7e(2).
WSMRR 380-5	(WSMR Information Security Program). Cited in paragraph 9k(1).

WSMRR 385-15	(Safety Standing Operating Procedures). Cited in paragraphs 7b(1)(g), 8b(9).
WSMRR 405-1	(Real Estate and Management). Cited in paragraph 8b(4).
WSMRR 702-4	(Purchase Descriptions and Support Documents). Cited in paragraphs 8b(4), 9i.
Federal Acquisition Regulations	Cited in paragraph 8c.

Section II

Related Publications

AR 10-13	(US Army Communications Command)	AR 530-2	(Communication Security).
		DA Pamphlet 11-13	(Army Electromagnetic Compatibility Program Guide).
AR 105-1	(Telecommunications Management)	DOD Directive 3200.11	(Major Range and Test Facility Base).
AR 105-24	(RF and Call Sign Assignments for Base Telecommunications-Electronics Activities)	DOD Directive 3222.3	(Department of Defense Electromagnetic Compatibility Program).
AR 105-70	(Amateur Radio Operations)	DOD Directive 4650.1	(Management and Use of the RF Spectrum).

Manual of Regulations and Procedures for Radio Frequency Management National Telecommunications and Information Administration (NTIA)

Memorandum of Understanding between CDR, USAWSMR and CDR, 7th Signal Command, USAISC

Host-Tenant Support Agreement between CDR, USAWSMR and CDR, USAISC-White Sands

Appendix B

Restricted Radio Frequency Band/Operations

Radio Frequency Band (MHz)	Operations
30-300 VHF and 300-3000 UHF	Voice communications (All channels which are used on a shared basis and not assigned to a specific project or for a specific purpose
225-260	Telemetry (All operations, even though scheduled, will be on a noninterference basis to/from non-WSMR controlled emitters.)
4[illegible]-550	Command control/destruct (including range safety)
1215-1400	Radars/Transponders
1435-1535	Telemetry
1710-1850	Scorer/MDI systems (transportable and air-ground data and video links)
2200-2290	Telemetry
2310-2390	Telemetry
2[illegible]-3500	Radars/Transponders
4400-4990	Scorer/MDI Systems (transportable and air-ground data and video links)
5250-5925	Radars/Transponders
8500-10, 5000	Radars/Transponders
Any/All	Electronic countermeasures (all surface and in-flight ECM)
Any/All	Any RFA in which a scheduling requirement is stated as a condition of assignment

Appendix C

Commonly Used-Authorized Prowords

Proword	Explanation
BREAK	I hereby indicate the separation of the text from other portions of the message.
CORRECTION	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted. An error has been made in this transmission (or message indicated). The correct version is __________. That which follows is a corrected version in answer to your request for verification.
DISREGARD THIS TRANSMISSION	This transmission is in error. Disregard it. (This proword will not be used to cancel any message that has been completely transmitted and for which receipt or acknowledgement has been received.)
DO NOT ANSWER	Stations called are not to answer this call, receipt for this message, or otherwise to transmit in connection with this transmission. When this proword is employed, the transmission will be ended with the proword "OUT."
FIGURES	Numerals or numbers follow.
I READ BACK	The following is my response to your instructions to read back.
I SAY AGAIN	I am repeating transmission or portion indicated.
I SPELL	I will spell the next word phonetically.
I VERIFY	That which follows has been verified at your request and is repeated. To be used only as a reply to VERIFY.
OUT	This is the end of my transmission to you and no answer is required or expected.
OVER	This is the end of my transmission to you and a response is necessary. Go ahead; transmit.
ROGER	I have received your last transmission satisfactorily.
SAY AGAIN	Repeat all of your last transmission. Followed by identification data means "Repeat __________ (portion indicated)."
SILENCE (Repeated three or more times)	Cease transmissions on this net immediately. Silence will be maintained until lifted. (When an authentication system is in force, the transmission posing silence is to be authenticated.)
SILENCE LIFTED	Silence is lifted. (When an authentication system is in force, the transmission lifting silence is to be authenticated.)

Proword	Explanation
THIS IS	This transmission is from the station whose designator immediately follows.
[illegible]	I have received your message, understand it, and will comply. (To be used only by the addressee. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.)
[illegible]	Your last transmission was incorrect. The correct version is ______________.

Appendix D

Phonetic Alphabet and Pronunciation of Numerals

Phonetic Alphabet

Letter	Phonetic	Spoken as	Letter	Phonetic	Spoken as
A	ALFA	AL FAH	N	NOVEMBER	NO VEM BER
B	BRAVO	BRAH VOH	O	OSCAR	OSS CAH
C	CHARLIE	CHAR LEE or	P	PAPA	PAH PAH
		SHAR LEE	Q	QUEBEC	KEH BECK
D	DELTA	DELL TAH	R	ROMEO	ROW ME OH
E	ECHO	ECK OH	S	SIERRA	SEE AIR RAH
F	FOXTROT	FOKS TROT	T	TANGO	TANG GO
G	GOLF	GOLF	U	UNIFORM	YOU NEE FORM or
H	HOTEL	HOH TELL			OO NEE FORM
I	INDIA	IN DEE AH	V	VICTOR	VIK TAH
J	JULIETT	JEW LEE ETT	W	WHISKEY	WISS KEY
K	KILO	KEY LOH	X	XRAY	ECKS RAY
L	LIMA	LEE MAH	Y	YANKEE	YANG KEY
M	MIKE	MIKE	Z	ZULU	ZOO LOO

Pronunciation of Numerals

Numeral	Spoken as	Numeral	Spoken as
0	ZE-RO	5	FIFE
1	WUN	6	SIX
2	TOO	7	SEV-EN
3	TREE	8	AIT
4	FOW-ER	9	NIN-ER

(NOTE: Syllables underlined carry the accent.)

Appendix E

Associated Public Safety Communications Officers (APCO) Ten Signal

Interpretation, where required, is indicated by wording in parentheses. (Blank numbers are not to be used since no designations have been given to date by APCO. The numbers are reserved for future use.)

10-1	Unable to copy - change location
10-2	Signals good
10-3	Stop transmitting
10-4	Acknowledgement
10-5	Relay
10-6	Busy - standby unless urgent
10-7	Out of service (give location and telephone number)
10-8	In service
10-9	Repeat
10-10	Fight in progress
10-11	Dog case (indicate nature, i.e., bite, rabid, injured)
10-12	Standby [illegible]
10-13	Weather and road report
10-14	Report of prowler (give location
10-15	Civil disturbance
10-16	Domestic trouble (give location)
10-17	Meet complainant (give location)
10-18	Complete assignment quickly
10-19	Return to __________
10-20	Location
10-21	Call __________ by telephone
10-22	Disregard
10-23	Arrived at scene
10-24	Assignment completed
10-25	Report in person to (meet)
10-26	Detaining subject, expedite
10-27	Drivers license information
10-28	Vehicle registration information
10-29	Check records for wanted
10-30	Illegal use of radio
10-31	Crime in progress
10-32	Man with gun (give location)
10-33	EMERGENCY
10-34	Riot (give location)
10-35	Major crime alert (nature of crime)
10-36	Correct time
10-37	Investigate suspicious vehicle
10-38	Stopping suspicious vehicle (give station complete description before stopping)

10-39	Urgent - use light and siren
10-40	Silent run - no light or siren
10-41	Beginning tour of duty
10-42	Ending tour of duty
10-43	Information
10-44	Request permission to leave patrol ________ for ________
10-45	Animal carcass in ________ lane at ________
10-46	Assist motorist (give location)
10-47	Emergency road repairs needed
10-48	Traffic standard needs repairs
10-49	Traffic light out
10-50	Accident - F-fatal, PI-personal injuries, PD-property damage
10-51	Wrecker needed
10-52	Ambulance needed
10-53	Road blocked
10-54	Livestock on highway
10-55	Intoxicated driver
10-56	Intoxicated pedestrian
10-57	Hit and run - F, PI, PD (give location)
10-58	Direct traffic
10-59	Convoy or escort
10-60	Squad in vicinity (give location)
10-61	Personnel in area
10-62	Reply to message
10-63	Prepare to make written copy
10-64	Message for local delivery
10-65	Net message assignment
10-66	Message cancellation
10-67	Clear to read net message
10-68	Dispatch information
10-69	Message received
10-70	Fire alarm (give location)
10-71	Advise nature of fire (size, type, and contents of building)
10-72	Report progress of fire
10-73	Smoke report
10-74	Negative
10-75	In contact with
10-76	En route
10-77	ETA (estimated time of arrival)
10-78	Need assistance
10-79	Notify coroner
10-80	
10-81	
10-82	Reserve lodging
10-83	

10-84	If meeting ________ advise ETA
10-85	Will be late
10-86	
10-87	Pick up checks for distribution
10-88	Advise present telephone number of ________
10-89	
10-90	Bank alarm (give location)
10-91	Unnecessary use of radio
10-92	
10-93	Blockade
10-94	Drag racing
10-95	
10-96	Mental subject
10-97	
10-98	Prison or jail break
10-99	Records indicated wanted or stolen

Appendix F

Standard Frequency Action Format

Item	Designator	Remarks
005	CLA	SECURITY CLASSIFICATION
006		SECURITY CLASSIFICATION MOD
010	TYA	TYPE OF ACTION
101	FID	FRRS ID
102	SER	AGENCY SERIAL NUMBER
103	AUT	IRAC DOCKET NUMBER
104	AUT	ASSIGNMENT AUTHORITY
105	LSN	LIST SERIAL NUMBER
106	DLS, DLD	SERIAL REPLACED, DELETE DATE
108	DOC	DOCKET NUMBERS OF OLDER AUTHORIZATION
110	FRQ, FRB	FREQUENCY(IES)
111	FBE	EXCLUDED FREQUENCY BAND
112	OPF	OPERATING FREQUENCY(IES)
113	STC	STATION CLASS
114	EMS	EMISSION
115	PWR	POWER
130	TME	TIME
140	RQD	REQUIRED DATE
141	EXD	EXPIRATION DATE
142	REV	REVIEW DATE
144	RTN	IRAC RECORD INDICATOR, ROUTINE AGENDA ITEM
145	IFRB	INTERNATIONAL REGISTRATION
146	TNK	DCS TRUNK ID
147	JNT	JOINT AGENCIES
151	CRLC	"C" FOR CANADIAN COORDINATION AND "M" FOR MEXICAN COORDINATION, OR "B" FOR BOTH
200	AGEN	RESPONSIBLE AGENCY
201	--	UNIFIED/SPECIFIED COMMAND

NOTE: This list may also be used to cross reference DA Form 2212 items currently in overnment master files.

Item	Designator	Remarks
202	--	UNIFIED COMMAND SERVICE
203	BUR	AREA FMO/BUREAU
204	--	COMMAND
205	--	SUB COMMAND
206	--	SUB SUB COMMAND
207	XUNE	OPERATING UNIT
208	NET	USER NET/CODE
300	XSC	STATE, COUNTRY
301	XAL	ANTENNA LOCATION
302	XUNE, XRC	STATION CONTROL
303	XLA, XLG	ANTENNA COORDINATES
304	XCL	CALL SIGN
306	XMR	AUTHORIZED MILEAGE RADIUS
314	XOBJ	SDC OBJECT NUMBER
315	XIN	EQUATORIAL INCLINATION ANGLE
316	XAE	APOGEE (STATUTE MILES)
317	XPE	PERIGEE (STATUTE MILES)
318	XPD	PERIOD OF ORBIT
319	XNR	NUMBER OF SATELLITES
321	SPD	POWER DENSITY
340	TYT, EQT	EQUIPMENT NOMENCLATURE
341	NRM, SYS	NUMBER OF EQUIPMENT, SYSTEM NAME
343	JFA	EQUIPMENT ALLOCATION STATUS
345	TUN	RADAR TUNABILITY
346	PDD	PULSE DURATION
347	PRR	PULSE REPETITION RATE
349	TYL, NFL	TYPE OF LASER, NUMBER OF LASERS
354	XAT(XAD)	ANTENNA NAME
355	XAK	ANTENNA NOMENCLATURE
356	XAD	ANTENNA DIMENSIONS
357	XGN(XAD)	ANTENNA GAIN

Item	Designator	Remarks
358	XEL(XAD)	ANTENNA ELEVATION
359	XAH(XAD)	ANTENNA FEED POINT HEIGHT
360	XBW	ANTENNA BEAMWIDTH
362	XAZ	ANTENNA ORIENTATION
363	XAP	ANTENNA POLARIZATION
400	RSC	STATE/COUNTRY
401	RLOC, RAL	ANTENNA LOCATION
402	--	RECEIVER OPERATING UNIT
403	RLA, RLG	ANTENNA COORDINATES
404	ACI	CALL SIGN
406	RMR	AUTHORIZED MILEAGE RADIUS
407	PATH	PATH LENGTH
408	RPT	REPEATER INDICATOR
414	ROBJ	SOC OBJECT NUMBER
415	RIN	EQUATORIAL INCLINATION ANGLE
416	RAE	APOGEE
417	RPE	PERIGEE
418	RPD	PERIOD OF ORBIT
419	[illegible]	NUMBER OF SATELLITES
440	TYP, [illegible]	EQUIPMENT NOMENCLATURE
442	[illegible]EA	EQUIPMENT ALLOCATION STATUS
454	RAT (RAD)	ANTENNA NAME
455	RAN	ANTENNA NOMENCLATURE
456	RAD	ANTENNA DIMENSIONS
457	RGN (RAD)	ANTENNA GAIN
458	REL (RAD)	ANTENNA ELEVATION
459	RAH (RAD)	ANTENNA FEED POINT HEIGHT
460	RBW	ANTENNA BEAMWIDTH
462	RAZ	ANTENNA ORIENTATION
463	RAP	ANTENNA POLARIZATION
470	SNT	SPACE STATION, RECEIVE NOISE TEMPERATURE

Item	Desigrator	Remarks
471	[illegible]	EARTH STATION, RECEIVE SYSTEM NOISE TEMPERATURE
472	[illegible]	EQUIVALENT SATELLITE LINK NOISE TEMPERATURE
[illegible]	NTS	IRAC NOTES (US&P ONLY)
[illegible]	NTZ	NOTES: FREE TEXT
5?2	RMKS	DESCRIPTION OF REQUIREMENT
[illegible]	[illegible]	AGENCY - FREE TEXT COMMENTS
[illegible]	SUP	SUPPLEMENTAL DETAILS
[illegible]	ASR	AUTHORIZED AREAS
[illegible]	ASA	AUTHORIZED STATES
[illegible]	FAO	FREQUENCY ACTION OFFICER
[illegible]	--	CONTROL/REQUEST NUMBER
[illegible]	TOS	TYPE OF SERVICE (NO LONGER USED. SEE ITEM 705.)
[illegible]	--	SYSTEM IDENTIFIER
[illegible]	[illegible]	NAVY DESIGNATOR
[illegible]	[illegible]	CINCPAC COMPLEMENT NUMBER
[illegible]	[illegible]	HOST COUNTRY DOCKET NUMBER
[illegible]	[illegible]	AERONAUTICAL SERVICE RANGE AND SERVICE HEIGHT
[illegible]	[illegible]	AREA FUNCTION NUMBER
715	MRFL	TRANSMITTER AREA MRFL NUMBER
716	--	PRIORITY CODE (EUROPE ONLY)
[illegible]	--	COORDINATION DATA/REMARKS
[illegible]	--	REQUESTER/DATE/REMARKS
804	--	TUNING RANGE (EUROPE ONLY)
805	--	DATE FREQUENCIES ARE REQUIRED (FOR EUROPE ONLY) IDENTIFICATION IF HOST
806	--	NOMINATIONS ARE ACCEPTABLE (FOR EUROPE ONLY)
807	--	FREQUENCIES TO BE DELETED (FOR EUROPE ONLY)

Glossary

Section I

Abbreviations

ACP	Allied Communication Publication
AFC	Area Frequency Coordinator
APCO	Associated Public Safety Communications Officer
CB	citizens band
C-E	Communications-Electronics
CP	cardiac pacemakers
DA	Department of the Army
DOD	Department of Defense
ECM	electronic countermeasures
EED	electro-explosive devices
ED	electronic device
EIRP	equivalent isotropically radiated power
EMC	electromagnetic compatibility
EMI	electromagnetic interference
FAR	Federal Acquisition Regulations
FCC	Federal Communication Commission
FSP	full-scale production
FSS	frequency surveillance stations
GHz	gigahertz
Hz	Hertz
IRAC	Interdepartment Radio Advisory Committee
JFP	Joint Frequency Panel
kHz	kilohertz
LCMM	life cycle management model
LP	limited production
LPD	low power devices
LRIP	low rate initial production
MCEB	Military Communications-Electronic Board
MHz	megahertz
MIJI	meaconing, intrusion, jamming, and interference
MIPR	military interdepartmental purchase request
NCS	net control stations
NTIA	National Telecommunications and Information Administration
O	ordnance
P	personnel
PVI	positive voice identification
RADHAZ	radiation hazard
RF	radio frequency
RFA	radio frequency authorization
RFI	radio frequency interference
ROP	radio operator permit
RPO	radiation protection officer
RR	radio regulations

RSC Range Scheduling Committee

SCO Systems Control Office

SFAF station frequency action format

SIGSEC signal security

SOP standing operating procedure

THz terahertz

UDS universal documentation system

UHF ultra high frequency

VF volatile fuels

VHF very high frequency

Section II

Terms

(Parenthetical expressions; following certain definitions are indicative of the source from which taken e.g., *RR (Radio Regulations)*, NTIA (National Telecommunications and Information Administration), ACP (Allied Communication Publication).)

Allocated (verb)
The process of establishing radio frequency (RF) bands or specific RF's for the performance of specific functions or services; frequently this includes the designation of specific equipment to perform the function.

Allocation (noun)
The RF band or specific RF's and any associated conditions or limitations, designated to perform a specific function by the act of allocation, as for **allocated.** (Note: An RF allocation authorization does not convey authority to actually operate transmitting equipment; an RF assignment is required and a request for same can be processed only after an allocation authorization has been consummated.)

Assign (verb)
The command process of authorizing a specific RF or an RF band, to be used at a certain station, under specified conditions of operation.

Assigned frequency
The center of the RF band assigned to a station (SP). The frequency coinciding with the center of the frequency band in which the station is authorized to work. The assigned frequency does not necessarily correspond to any frequency in an emission. (ACP 167)

Assigned frequency band
The frequency band the center of which coincides with the frequency assigned to the station and the width of which equals the necessary bandwidth plus twice the absolute value of the frequency tolerance. (RR).

Assignment (noun)
The RF band or specific RF and any associated conditions or limitations, authorized for use at a given station by the act of assignment, as for verb **assign.**

Authorized bandwidth
The necessary bandwidth (bandwidth required for transmission and reception of intelligence) and does not include allowance for transmitter drift or doppler shift. (NTIA)

Communications-electronics (C-E)
The discipline which embraces design, development, installation, operation, and maintenance of electronics and electromechanical systems, subsystems, equipment and devices associated with all forms of military communications.

C-E environment
A description, actual or estimated, of C-E materiel characteristics, units to which the materiel is assigned, and the way the C-E materiel is distributed and used within a military operation typical of the time frame under consideration.

C-E materiel
All electrical and electronic systems, subsystems, and equipment which are dependent upon, or have an impact on, the use of the electro-magnetic spectrum.

Characteristic Frequency
A frequency which can be easily identified and measured in a given emission. (RR) (See definition for **RF**.)

Closed-Circuit system
An RF transmitter system in which the RF energy from the transmitter is intentionally dissipated in a dummy load or other type of power-absorbing device; a system in which the RF energy is contained within a shielded enclosure; a system used to check out transmitter performance without intentional radiation of RF energy.

Electromagnetic compatibility (EMC)
The ability of C-E equipment, subsystem, and systems, together with electromechanical devices (for example: vehicles, engine generators, and electrical tools), to operate in their intended operational environments without suffering or causing unacceptable degradation because of unwanted electromagnetic radiation or response. Electromagnetic compatibility embraces both susceptibility and vulnerability. Radio frequency interference reduction is an older term for electromagnetic compatibility and is considered to be synonymous with the newer term, electromagnetic compatibility, which is preferred.

Electromagnetic compatibility analysis
An investigation of the EMC of C-E materiel or concepts within their intended C-E environment.

Electromagnetic environment
The power flux density, energy spectral distribution, or power spectral distribution, either actual or estimated, as a function of three space coordinates, time and frequency.

Emergency
A situation of temporary duration resulting directly or indirectly from a national catastrophe or other occurrence that seriously affects the welfare of a community or of an area to the extent of endangering human life and property with which special communication facilities are required temporarily. (NTIA)

Frequency Management (or spectrum management)
The control of the RF spectrum through the process of RF allocation; RF assignment; RF surveillance and analysis of equipment research, development, test evaluation and operation; an RF records administration.

Frequency tolerance
The maximum permissible departure by the center frequency of the frequency band occupied by an emission from the assigned frequency, or by the characteristic frequency of an emission from the reference frequency. The frequency tolerance is expressed in parts in 10^6 (parts per million) or in hertz. (RR)

Hertz (Hz)
A unit of RF which is equivalent to one cycle per second. (NTIA)

Interference
Any harmful radiation, the source of which cannot be positively identified as locally generated spurious signals or technical difficulties, or other readily identifiable and easily correctable sources. For MIJI evaluation purposes, interference is any electromagnetic emission causing undesirable responses which degrade, disturb, or disrupt the design function of devices or systems which employ electromagnetic energy. (AR 105-3) (For frequency management purposes, the term "harmful interference" (in addition to that defined for **interference, harmful**) is also used to denote that type of interference which actually causes circuit outage on an RF as opposed to interference which is purely a source of annoyance.)

Interference analysis
The engineering techniques utilized to determine the location and identity of RF interference sources and to select the best means of eliminating or reducing their impact.

Interference, harmful
Any emission, radiation, or induction which endangers the functioning of a radio navigation service or of other safety services, or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service. (RR)

Intrusion
The intentional insertion of electromagnetic energy into transmission paths in any manner with the objective of deceiving operators or of causing confusion. (AR 105-3)

Jamming
The deliberate radiation, reradiation, or reflection of electro-magnetic energy with the object of impairing the use of electronic devices, equipment, or systems being used by an enemy. (AR 105-3)

Meaconing
A system of transmitting actual or simulated radio navigation signals for the purpose of confusing navigation. For example: Meaconing stations can cause inaccurate bearings to be obtained by aircraft, ships, or ground stations. (AR 105-3)

Necessary bandwidth
For a given class of emission (see Note below), the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions. Emissions useful for the good functioning of the receiving equipment as, for example, the emission corresponding to the carrier of reduced carrier systems, will be included in the necessary bandwidth. (RR)

NOTE: The authorized emission will be limited to the necessary bandwidth, type of modulation, and type of transmission authorized. For example: An A3 emission designator (amplitude modulation and the transmission of telephony/voice) does not include authority for any other type of transmission such as CW(A0), tone modulated telegraphy (A2), or encrypted telephony voice (A9).

Net (communications)
An organization of stations capable of direct communications on a common channel or frequency. (ACP 167)

Net control station (NCS)
A station designated to control traffic and enforce circuit discipline within a given net. (ACP 167)

Net, directed
A net in which no station other than the net control stations may communicate with any other station, except for the transmission of urgent messages, without first obtaining the permission of the net control station. (ACP 167)

Net, free
A net in which any station may communicate with any other station in the same net without first obtaining permission from the net control station to do so. (ACP 167)

Noninterference basis (NIB)
A condition of RF assignment, wherein an RF user must accept all interference caused by an established user and is further subject to silencing should established users experience interference therefrom.

Nonscheduled basis
Radio frequency users' specific RF and radiation time requirements which do not appear on the official Range Schedule but which have been authorized by the Systems Control Office (SCO) Operations Division, USAISC-White Sands).

Occupied bandwidth
The frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission. In some cases, for example, multi-channel frequency/division systems, the percentage of 0.5 may lead to certain difficulties in the practical application of the definitions of **occupied** and **necessary bandwidth**; in such cases, a different percentage may prove useful. (RR) (Maximum efforts will be made in equipment design and operations to maintain the occupied bandwidth of emissions of any transmission as closely as possible to the necessary bandwidth.)

Power-equivalent isotropically radiated power (EIRP)
The product of the power of an emission as supplied to an antenna the antenna gain in a given direction relative to an isotropic antenna. (RR)

Radio frequency authorization (RFA)
The document or power (authority) which legalizes the assignment of RF or RF's.

Radio frequency (RF) or radio waves (Hertzian waves)
Electromagnetic waves of frequencies lower than 3,000 GHz, propagated in space without artificial guide. (RR)

Radio frequency silence
A period during which all or certain RF equipment capable of radiation is kept inoperative. (ACP 167)

Reference frequency
A frequency having a fixed and specified position with respect to the assigned frequency. The displacement of this frequency with respect to the assigned frequency has the same absolute value and sign that the displacement of the characteristic frequency has with respect to the center of the RF band occupied by the emission. (See **Characteristic Frequency.**) (RR)

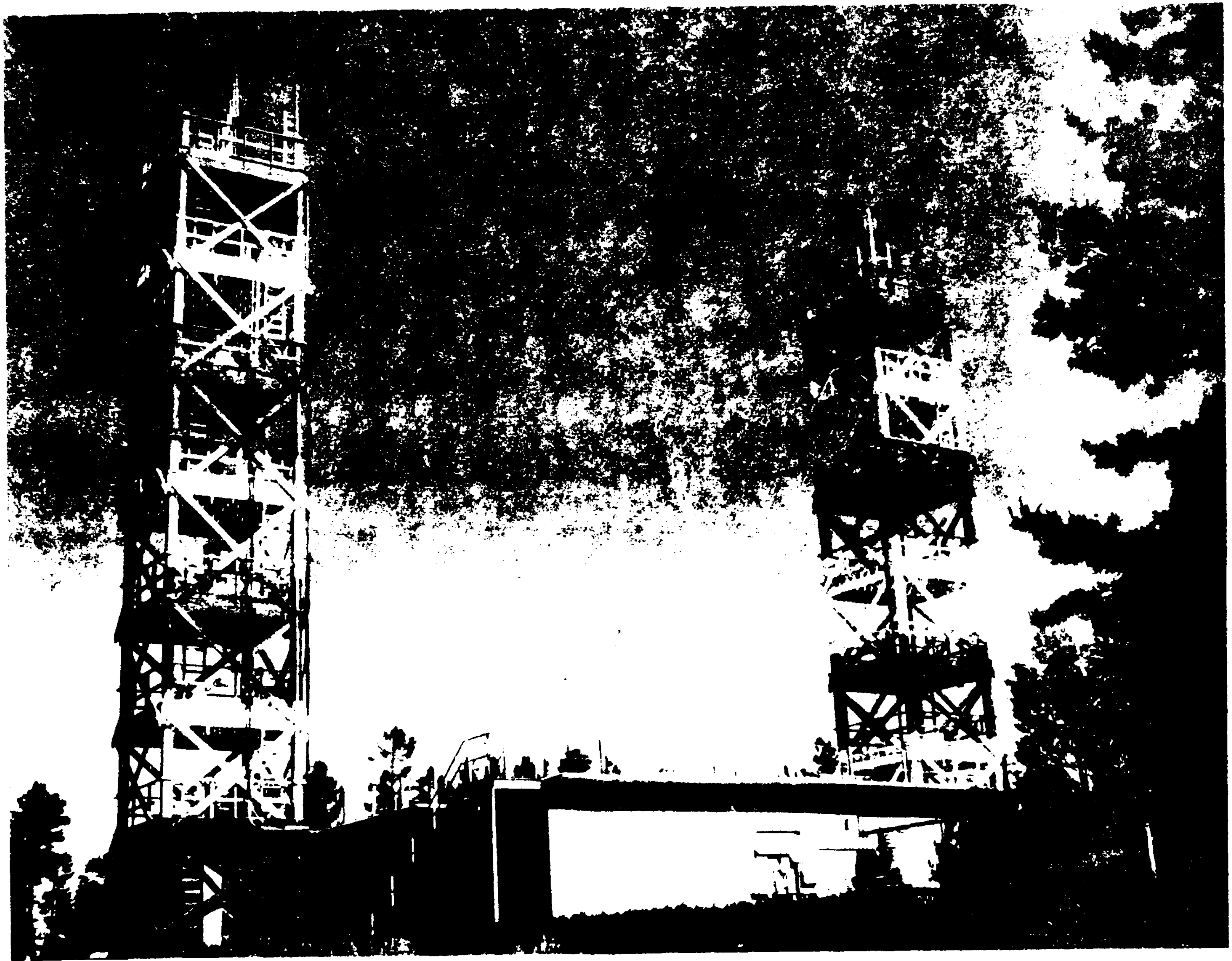
Scheduled basis
Radio frequency users who have coordinated and documented their proposed operations, including specific RF usage and required radiation time, with the Range Scheduling Committee.

Spacecraft
Any type of space vehicle, including drones, balloons, earth satellites and deep-space probes, intended to go beyond the major portion of the earth's atmosphere. Deep-space encompasses distances from the earth approximately equal to or greater than the distance between the earth and the moon. (RR)

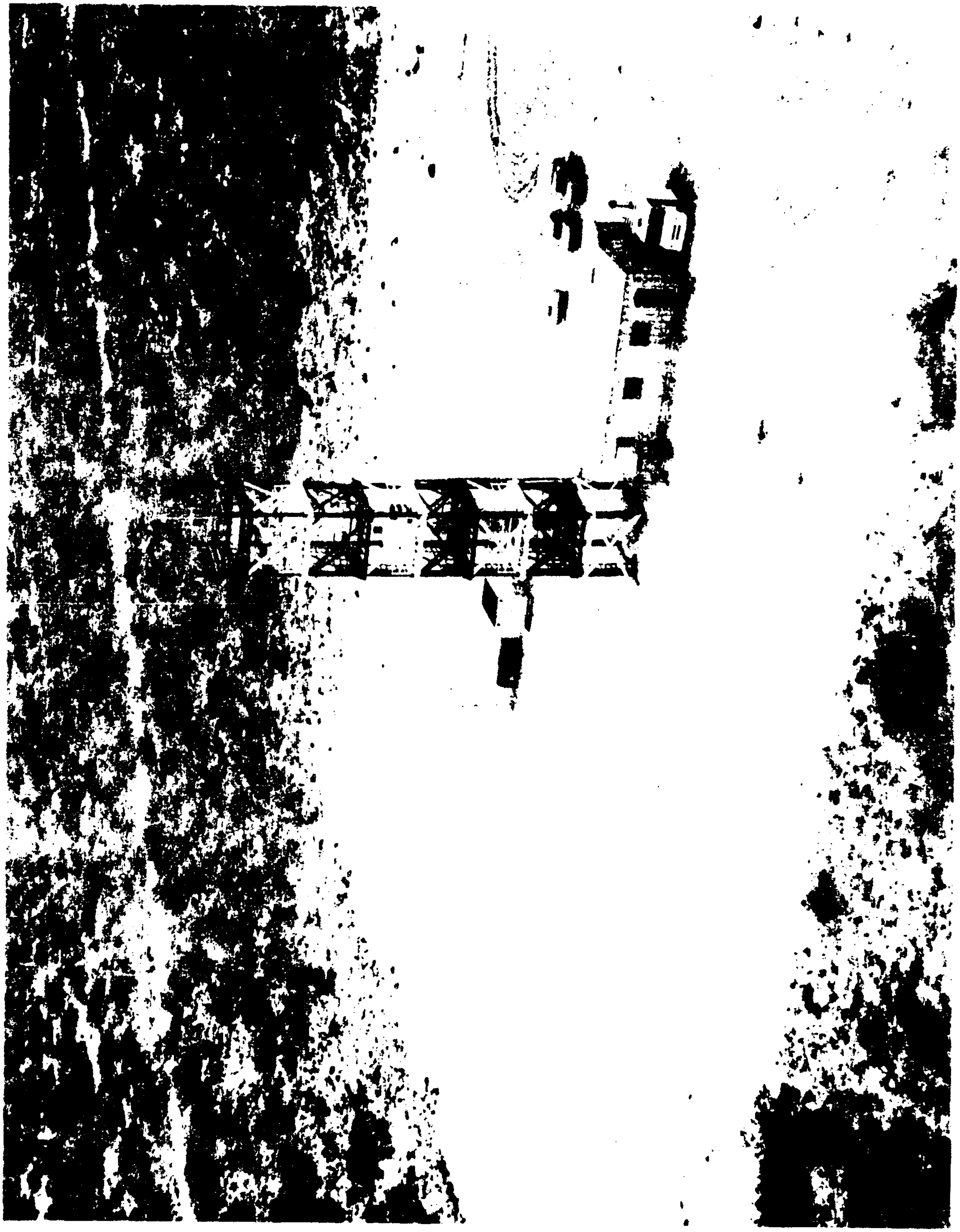
Spectrum management (or frequency management)
The control of the RF spectrum through the process of RF allocation; RF assignment; RF surveillance and analysis of equipment research, development, test evaluation, and operation; and RF records administration.

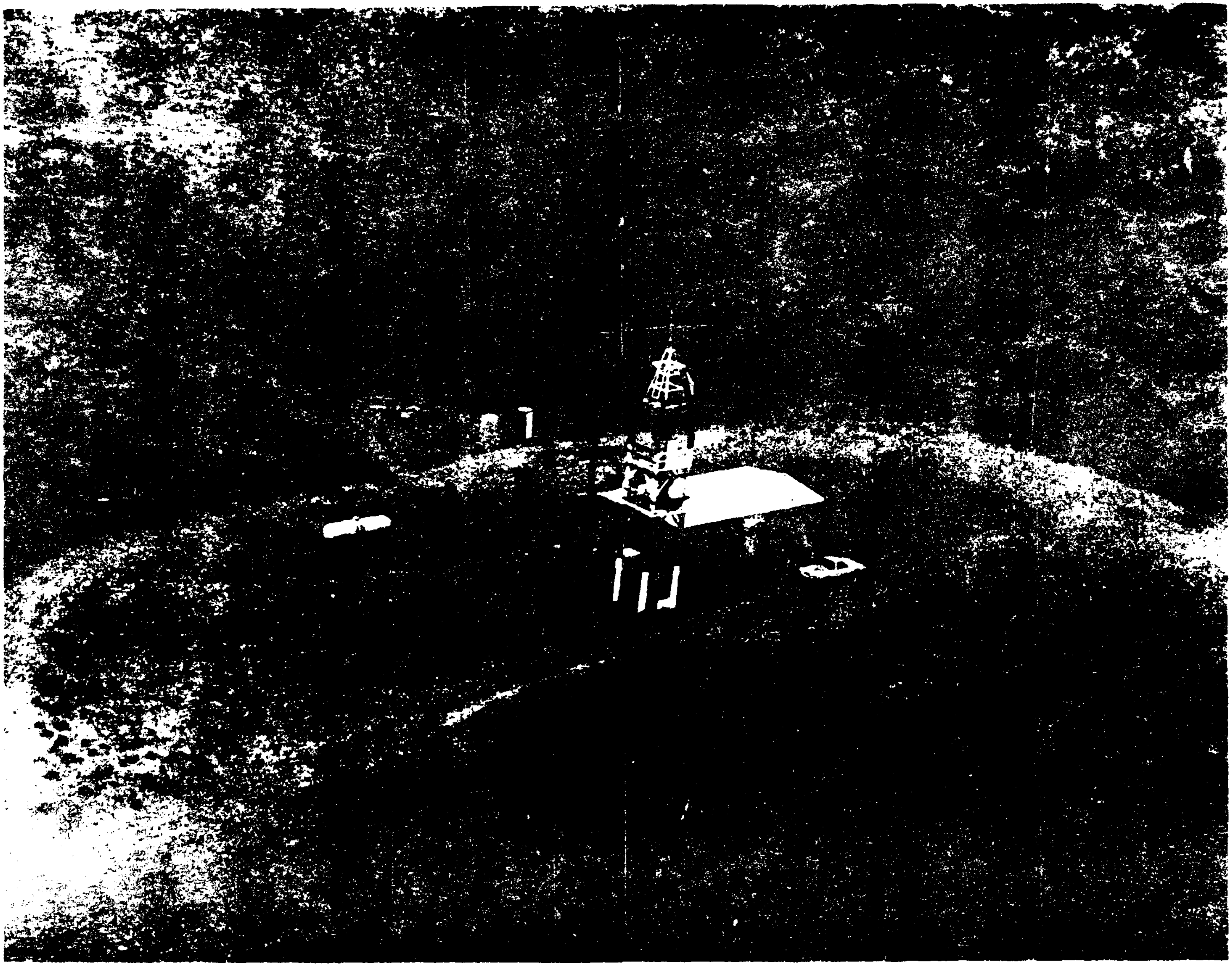
Spurious emission
Emission on a frequency or frequencies which are outside the necessary band, and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions and intermodulation products, but exclude emissions in the immediate vicinity of the necessary band which are a result of the modulation process for the transmission of information. (RR)

I-32 White Sands Missile Range Station

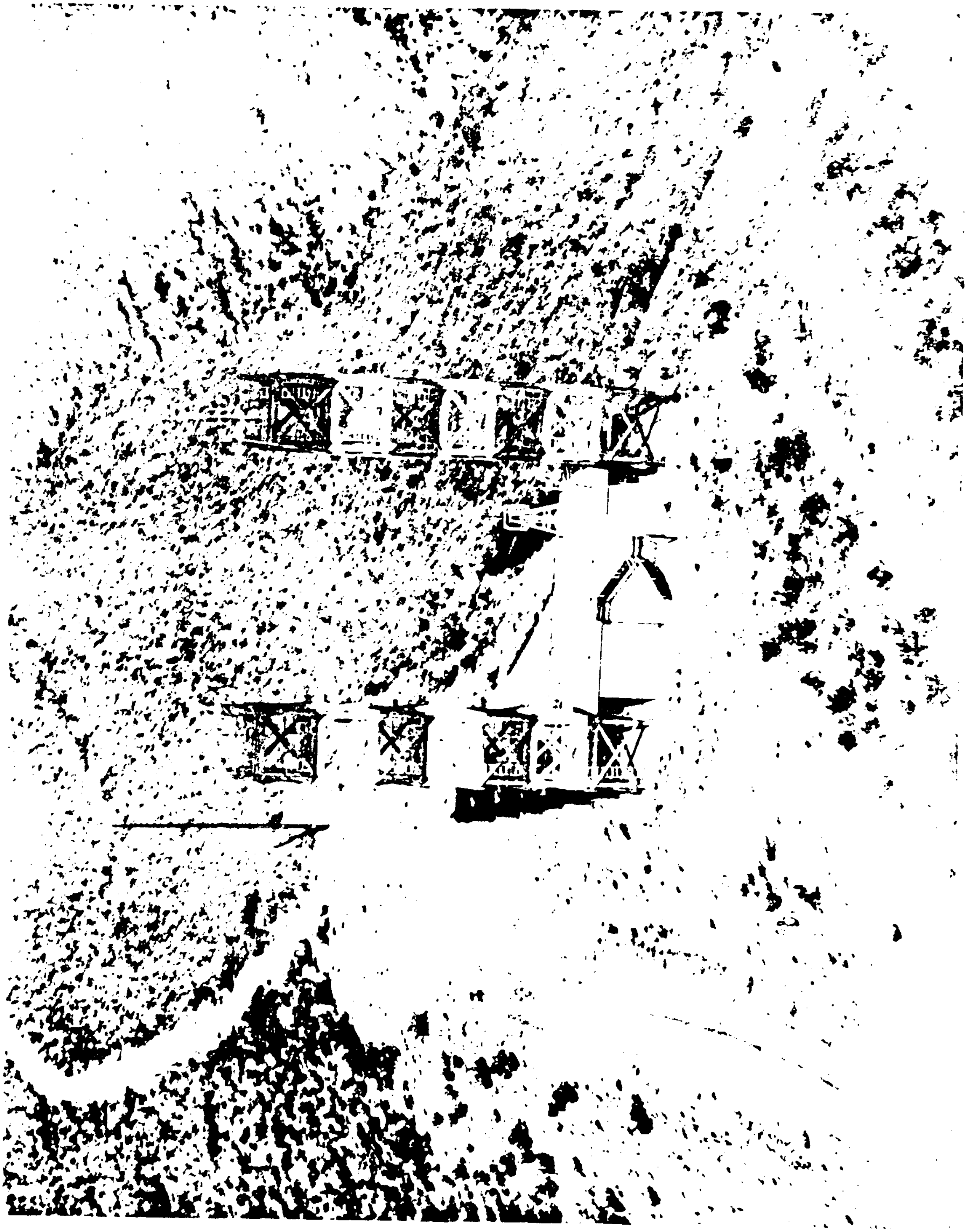


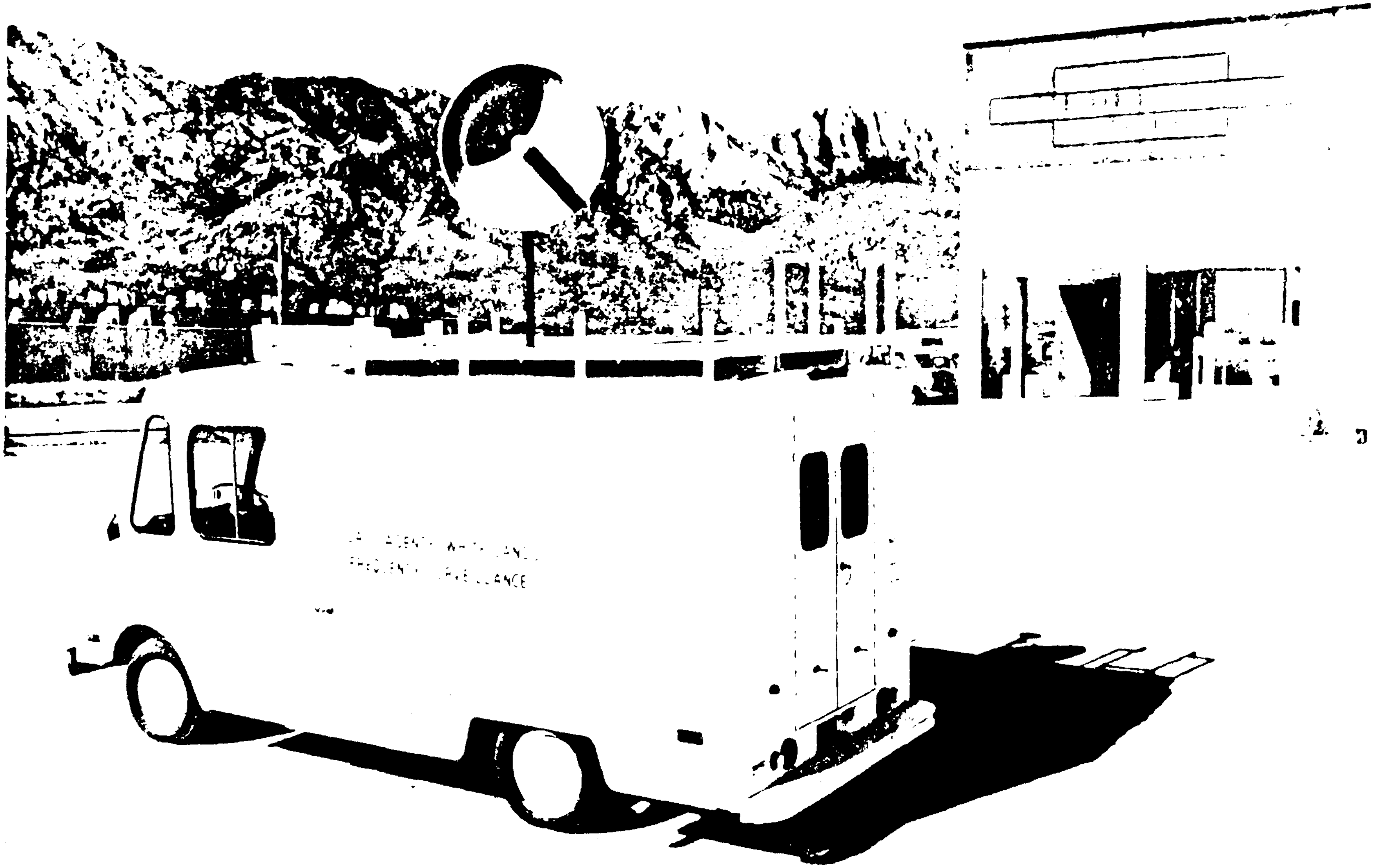
Sacramento Peak Station



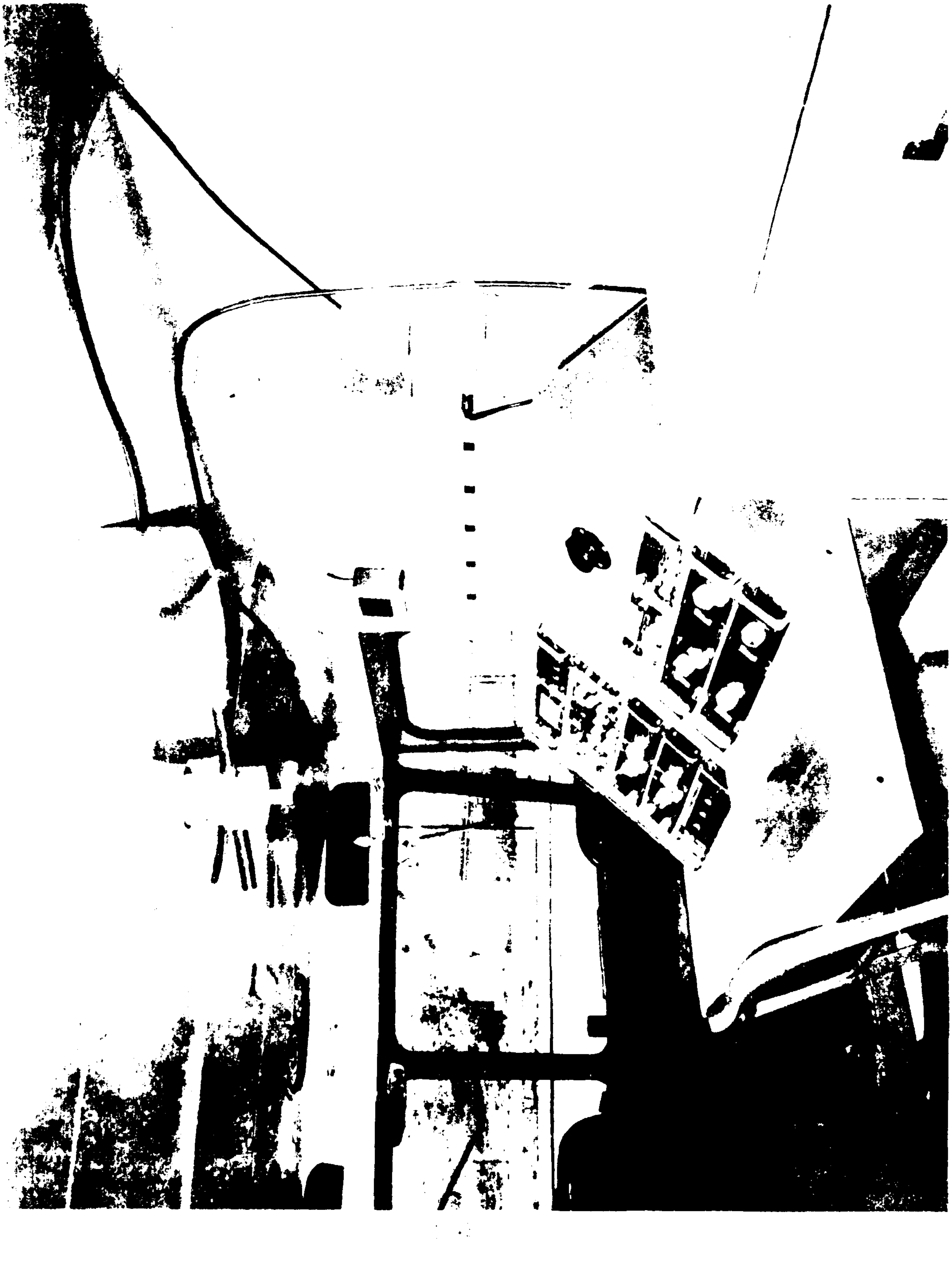


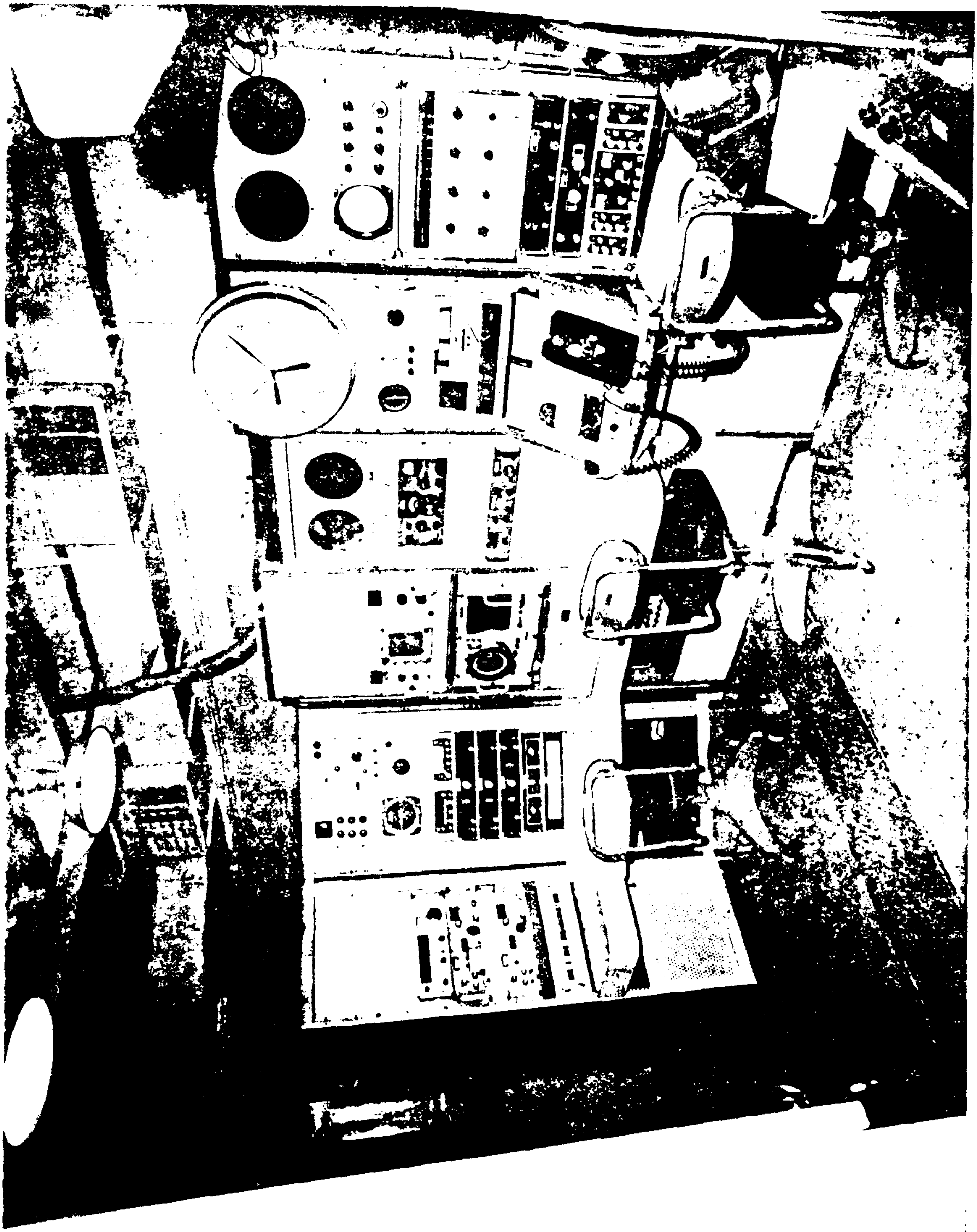
McGregor Range Station

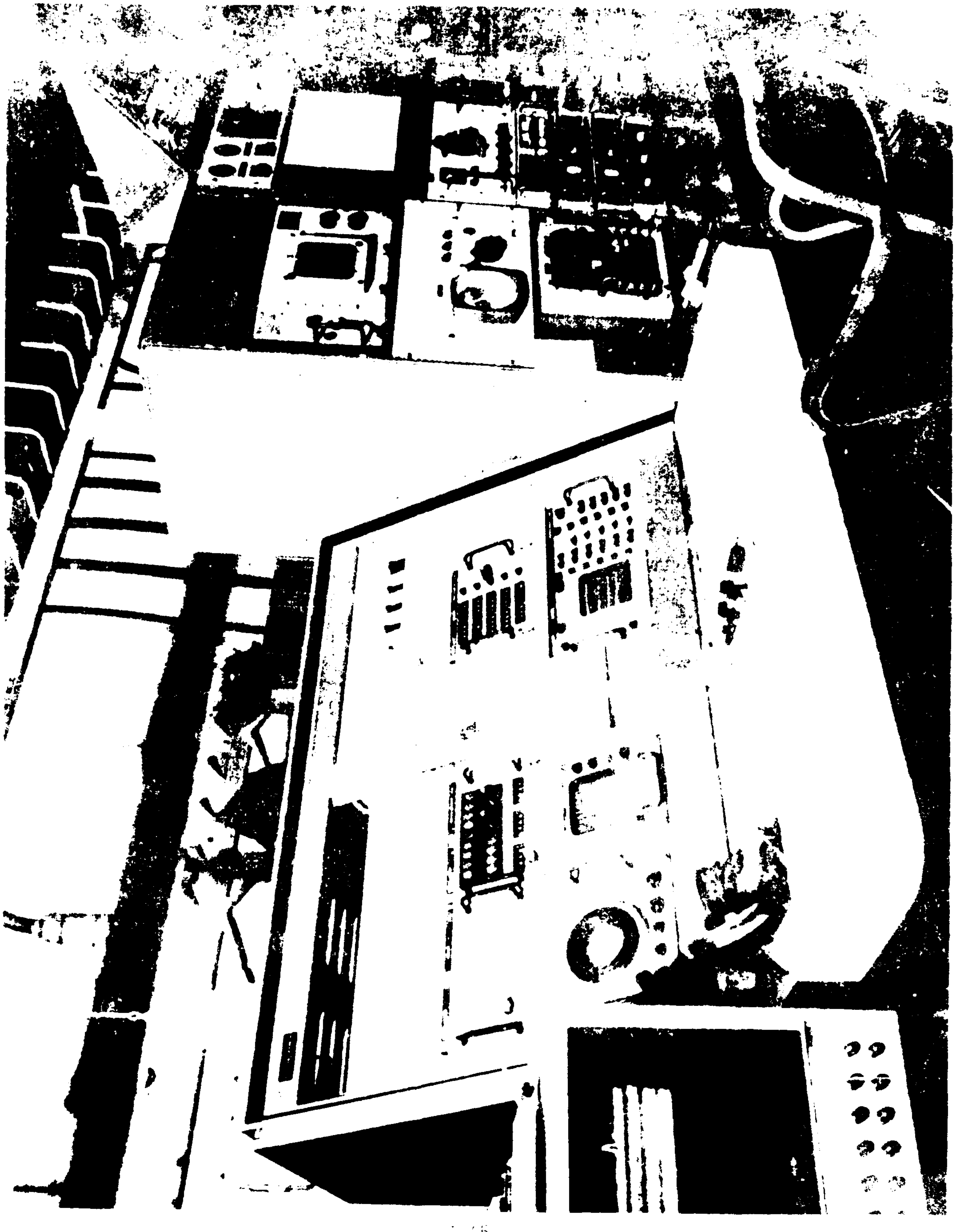




Frequency Surveillance Van







Inside of a Typical Station

APPENDIX J

U.S. ARMY YUMA PROVING GROUND

YUMA, ARIZONA

1. The Yuma PG Frequency Management Office (FMO) has very limited Frequency monitoring and surveillance capabilities. The FMO at YPG is using one IFR 1500 AM/FM monitoring system, Bearcat 300 scanner, and Regency MX5000 monitor. Additionally one vertical (Folded -5B omni II - Dipole VHF/UHF continuous coverage from (30 - 960 MHZ) is used with the IFR 1500. The receiver has the option of passing the signal thru 0-35 DB variable gain RF (40-900 MHZ) amplifier. A high output 20 db amp can be selected on the transmit side if so desired.

2. The IFR 1500 is composed of a signal generator, receiver, programmable audio tune generator, sweep generator, spectrum analyzer and duplex capabilities.

a. SIGNAL GENERATOR: The FM/AM-1500 signal generator is capable of generating modulated or unmodulated carrier signals within a range of 100 KHz to 999.9999 MHz (in 100 Hz steps), at the output level which is continuously variable from 0* to -128 dBm. The generator carrier signal may be AM or FM modulation signals originating from one or both of the FM/AM-1500 tone generators or by external sources applied through front panel modulation input connectors. The generator may also be voice modulated and keyed through the front panel microphone input connector.

All of the above described modulation sources, or any combination thereof, may be simultaneously applied to the carrier signal.

b. RECEIVER: The FM/AM-1500 receiver is a sensitive 2 uV quadruple conversion super-heterodyne receiver, capable of monitoring communications signals within a range of 300 KHz to 999.9999 MHz, in 100 Hz steps. Signals may be received "off-the-air" using an external antenna or by direct cable connection through the front panel TRANS/-40 dB duplex connector.

Associated receiver monitoring circuits include a frequency error meter, modulation meter, power meter, sinad meter, signal strength meter, frequency error and demodulated audio counters, spectrum analyzer and a 1 MHz oscilloscope.

c. PROGRAMMABLE AUDIO TONE GENERATORS: The FM/AM-1500 has two independently controlled variable tone generators which are capable of generating modulation signals with a range of 2 Hz to 30 KHz (in 0.1 Hz increments from 2 Hz to 9999.9 Hz and 1.0 Hz increments from 10 KHz to 30 KHz). The frequencies of both generators are keyboard selected and are displayed in the Tone 1 and Tone 2 data fields of the front panel LC.

In manual mode, the output level and modulation mode of each tone generator can be individually controlled by the associated Tone 1 and Tone 2 controls, while the modulation levels can be simultaneously monitored on the CRT or modulation meter.

Under menu control, the tone generator frequency amplitude and duration are all automatically controlled.

d. SWEEP GENERATOR: The FM/AM-1500 sweep function can be used to sweep RF and IF systems up through the full range of 1 to 1000 MHz, enabling the frequency response characteristics to be displayed on the FM/AM-1500 oscilloscope. The sweep generator function is also useful for aligning the amplifier IF and demodulator circuits, by applying the swept RF output to the UUT injection point and applying the demodulated output to the FM/AM-1500 scope/sinad connector.

e. SPECTRUM ANALYZER: Incorporated in the FM/AM-1500 is a unique full scan 1 to 1000 MHz spectrum analyzer which includes a minimum scan position of 1 KHz per division with a 300 Hz bandwidth. The FM/AM-1500 spectrum analyzer has eleven calibrated dispersion selections with bandwidths automatically selected with the analyzer dispersion setting. The center of the analyzer is always phase-locked to the receiver center frequency making it possible to positively identify displayed signals at a glance.

The FM/AM-1500 receiver remains fully functional for scan widths up through 1 MHz per division.

f. DUPLEX CAPABILITIES: In the duplex mode, the FM/AM-1500 has the capability of generating and receiving signals simultaneously. While the receiver section of the FM/AM-1500 is monitoring incoming signals transmitted via antenna, the FM/AM-1500 signal generator is simultaneously generating signals to stimulate the receiver section. The frequency of the generated signal from the FM/AM-1500 can be offset up to ±49.99 MHz from the received frequency, in 10 KHz steps.

Three methods of duplex testing are available to the FM/AM-1500 user:

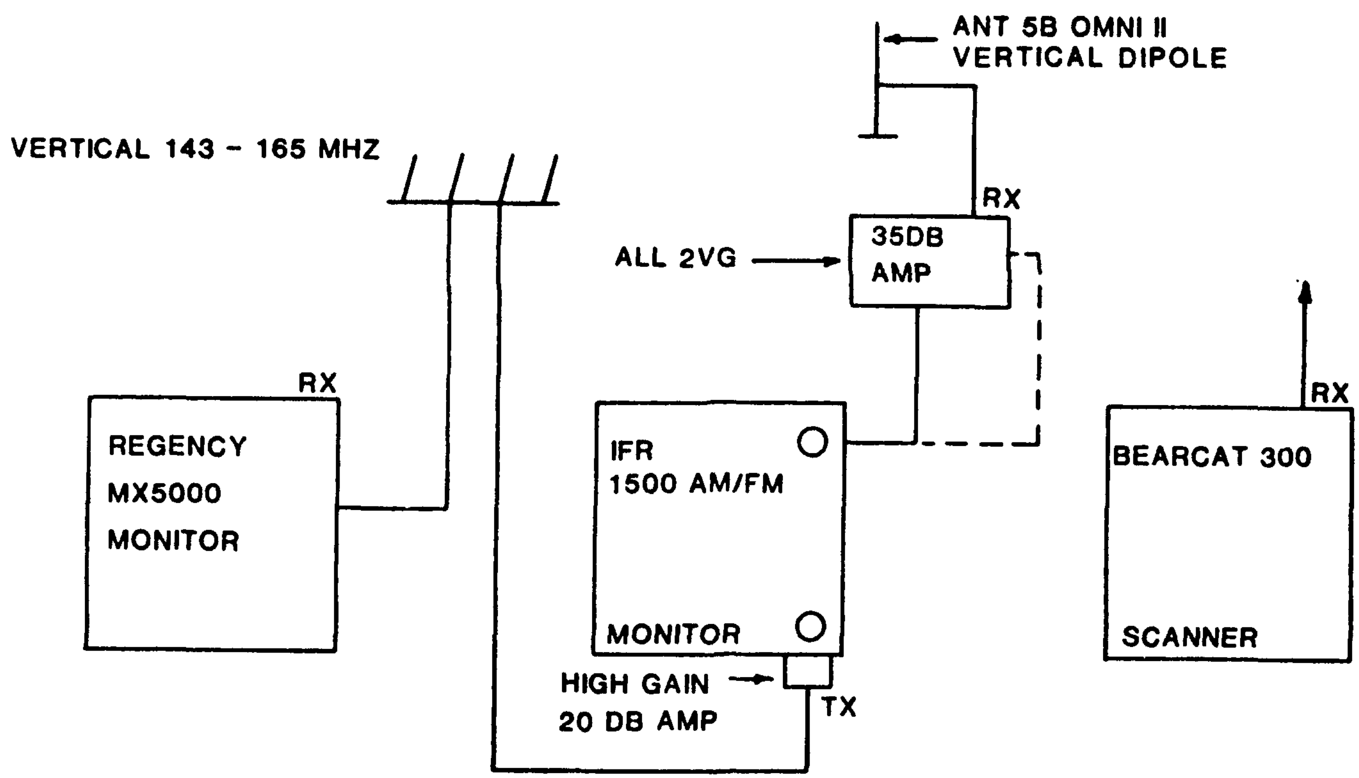
1. Duplex testing using separate transmit/receive lines.
2. Duplex testing using 1 common receive/transmit line.
3. "Off the air" duplex testing.

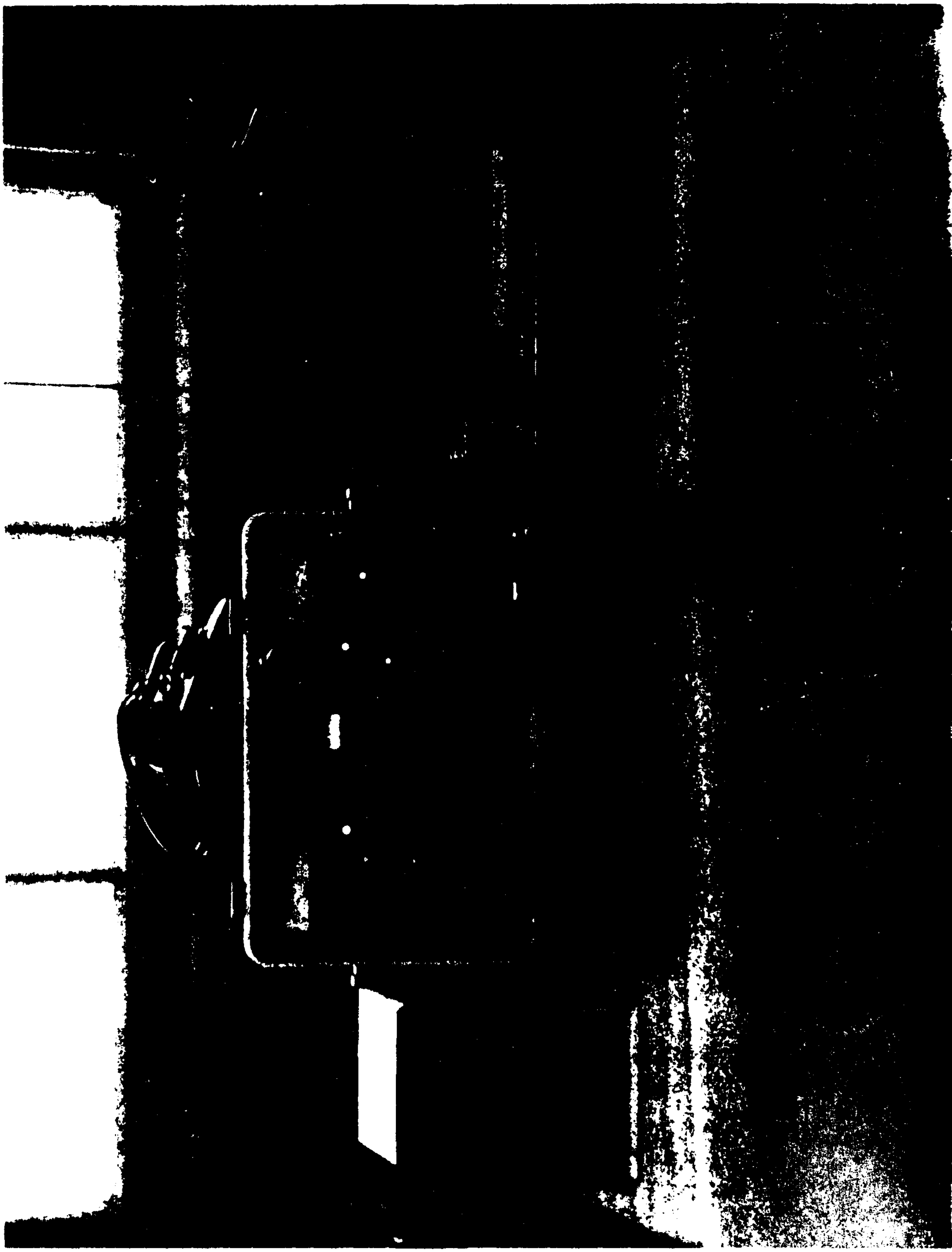
3. To augment the IFR we employ a regency MX-5000 receiver which can scan continuously from, 25-560 MHz or manually enter frequency up to 999 MHz.

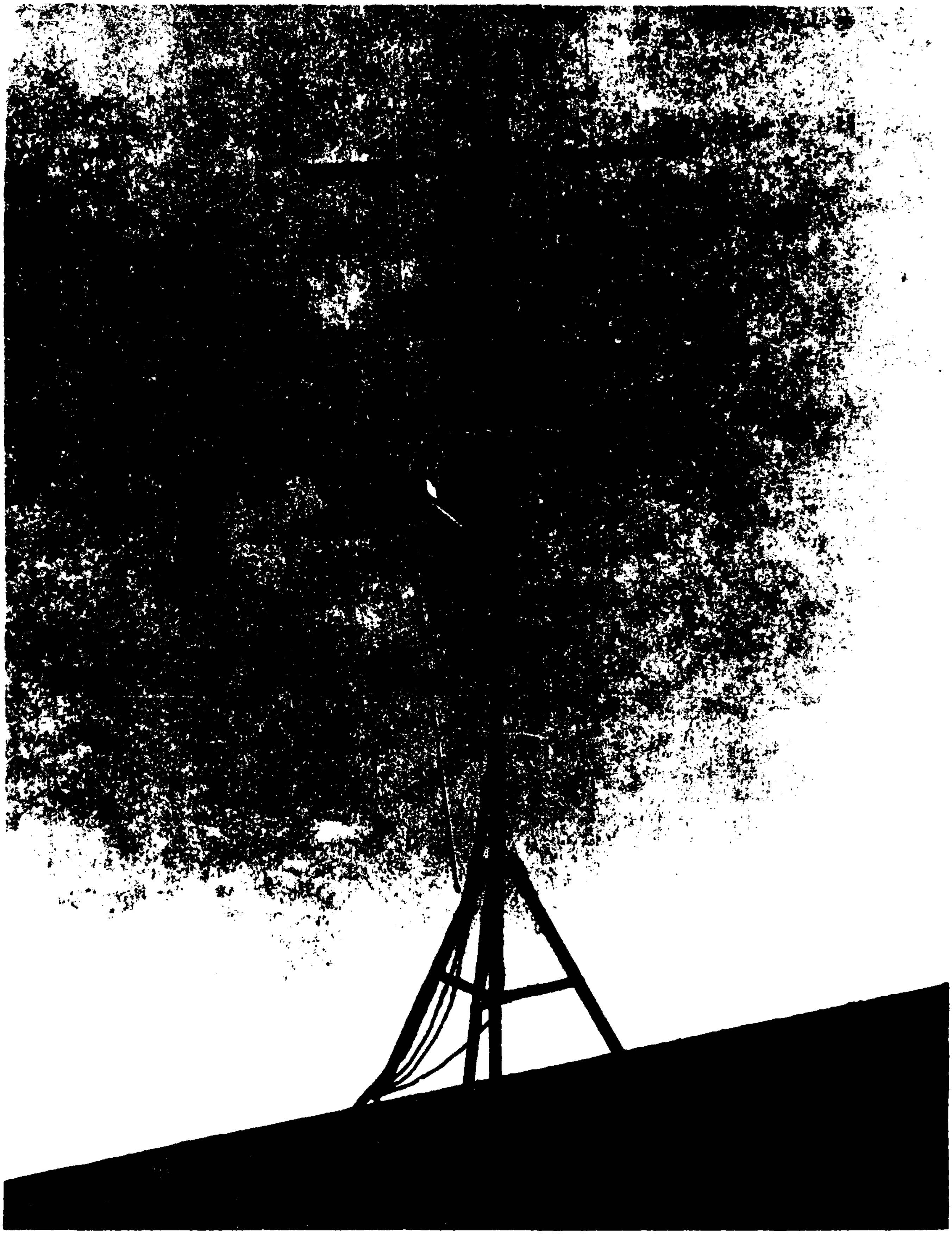
4. The above three monitoring system provide just a fraction of what is really needed at YPG, as the Range utilizes frequencies from .5 MHz to 40 GHz.

5. Additionally, the Bearcat 300 scanner a stand alone system allows us to monitor many civilian band frequencies and some military bands.

YUMA PROVING GROUND
FREQUENCY MONITORING FACILITY
BLOCK DIAGRAM







APPENDIX K

NASA/WALLOPS FLIGHT FACILITY

WALLOPS ISLAND, VIRGINIA

3.2 FREQUENCY MONITORING AND INTERFERENCE CONTROL

The purpose of frequency monitoring and interference control (FMIC) is to insure interference-free operations, to supply information on possible interfering transmitting sources, to monitor and report the operational characteristics of vehicle and ground support transmitters, and to investigate and compare the effects on AM, SSB, CW, and FM radio signals at various frequencies from the standpoint of both efficient use of the frequency spectrum and possible interference with test operations, and to determine that the Wallops operational frequency assignments and schedules are maintained within their limits. Interference control involves the location and identification of sources of electromagnetic radiation for the elimination or reduction of such interference to further safeguard range operations.

Frequency monitoring and interference control facilities consist of a station located in the Telecommunications Building, N-162, The station contains radio frequency instrumentation and appropriate omnidirectional and unidirectional antennas with antenna rotators and mounts to cover the frequency spectrum of 200 KHz to 12 GHz. See Figures 1-1, 1-2, 2-15, and 3-1, and Tables 3-1 and 3-2.

FMIC operations are being enhanced at GSFC/WFF and equipment shown on Tables 3-1 and 3-2 is subject to change as new equipment is added.

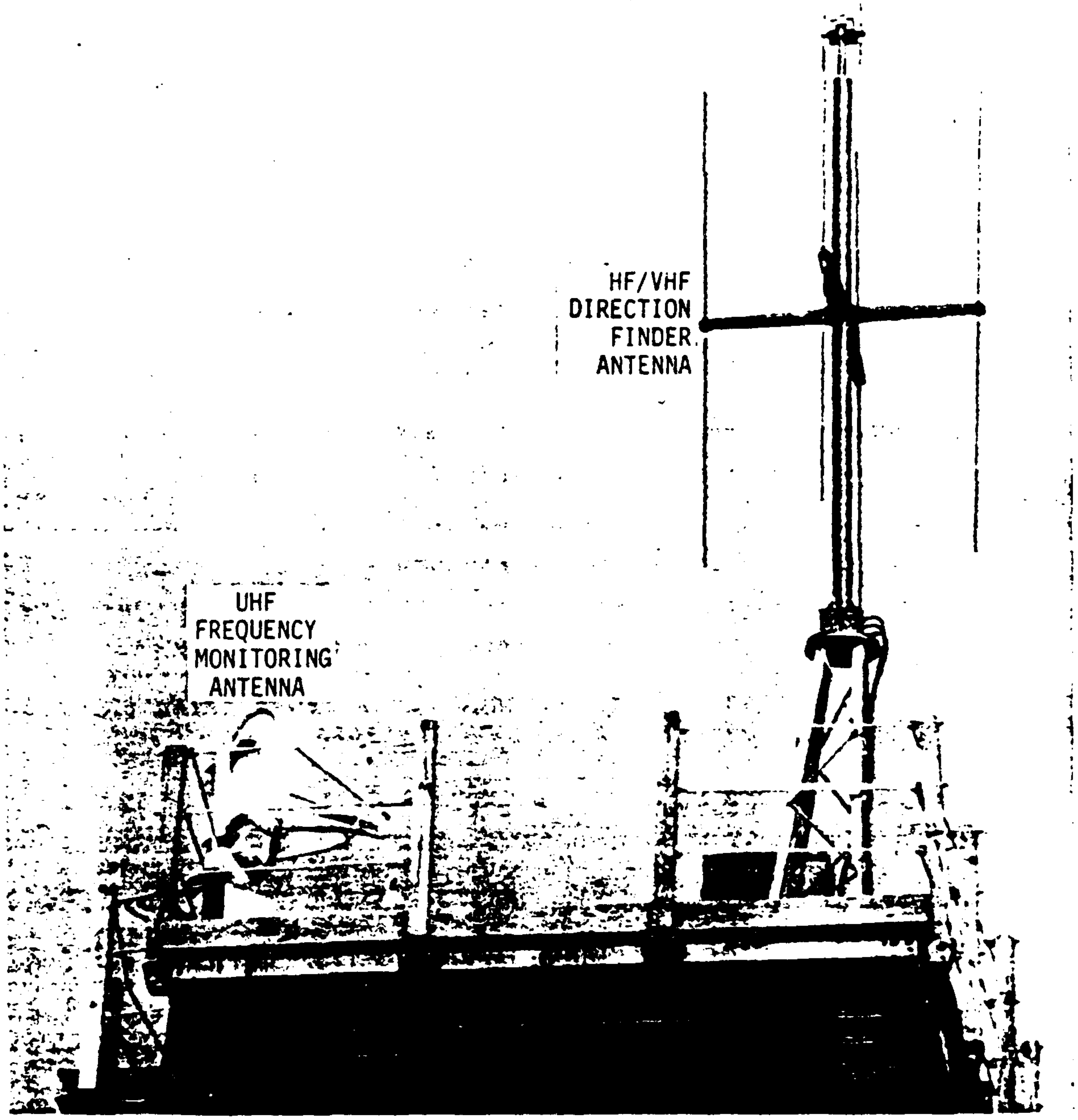


Figure 3-1. Frequency Monitoring & Interference Control Antenna Arrays (Near Building N-162)

TABLE 3-1
List of Equipment: FMIC

Equipment	Company	Appendix
BCR-55 UHF Receiver and BCD-29 Audio Frequency Decoder	Babcock Electronics Corp.	C.10
Type 5-124A Recording Oscillograph	Consolidated Electrodynamics Corporation	D.5
Model 8718 HF Tunable Receiver	Watkins-Jenkins	C.6
RS-111-1B-12B Receiving System	Collins Radio Co.	C.11
7580 Transfer Oscillator	Beckman Instruments	F.15
Spectrum Analyzer 855A RF and 8552B IF	Hewlett-Packard	F.16
901 VHF Tunable Receiver	Communications Electronics, Inc.	C.12
WJ-8617 B VHF/UHF Tunable Receiver	Watkins-Johnson	C.13
SM-9310B Signal Monitor	Communications Electronics, Inc.	F.8
MSR 904A Microwave Receiver with FCS-904 Frequency Counter Synthesizer	Micro-Tel Corp.	C.14

TABLE 3-2
List of Antenna Systems: FMIC

Equipment	Company	Appendix
WJ-9872A DF Antenna with WJ-8971A-7 Direction Finder	Watkins-Johnson Co.	E.17
CSC[2] Antenna Type 202180-1 with Type 203009 Rotator and Type 203011 Controller	TECOM Industries, Inc.	E.18

TABLE 3-1 (CON'T)

LIST OF EQUIPMENT: FMIC

EQUIPMENT	COMPANY
Direction Finding Processor, WJ-8971A with Direction Finding Antenna, WJ-9872A	Watkins-Johnson
Digitally Refreshed CRT, DC904 (used with MSR 904A Receiver)	Micro-Tel Corp.

3.2.1 Range Signal Analysis

In the Range Signal Analysis operation, range signals are analyzed using primarily those antennas with omnidirectional coverage. The outputs of the receivers are analyzed to determine the quality of signals emitting from range instrumentation and to assist in identifying electromagnetic radiation which interferes with range operation.

Frequency measurements are obtained by heterodyning a stable CW signal source with the received signal and providing direct counter frequency readout of the signal source, accurate to less than 3 parts in 10^{10}. The CW source is injected by a sampler probe into the RF transmission line simultaneous with the received signal to be measured. A means is provided to continuously vary the signal source output level for optimum heterodyning.

Patch panels are used to afford maximum flexibility of the recording units. Magnetic tape and graphic recorders are used with both range signal analysis and interference control portions of the spectrum surveillance system.

3.2.2 Interference Control

Interference control uses unidirectional antennas, receivers, and recorders to locate the signal source. Received signals are preamplified and distributed to patch panels in the interference control system for receiver selection based on requirements, and analysis and recording.

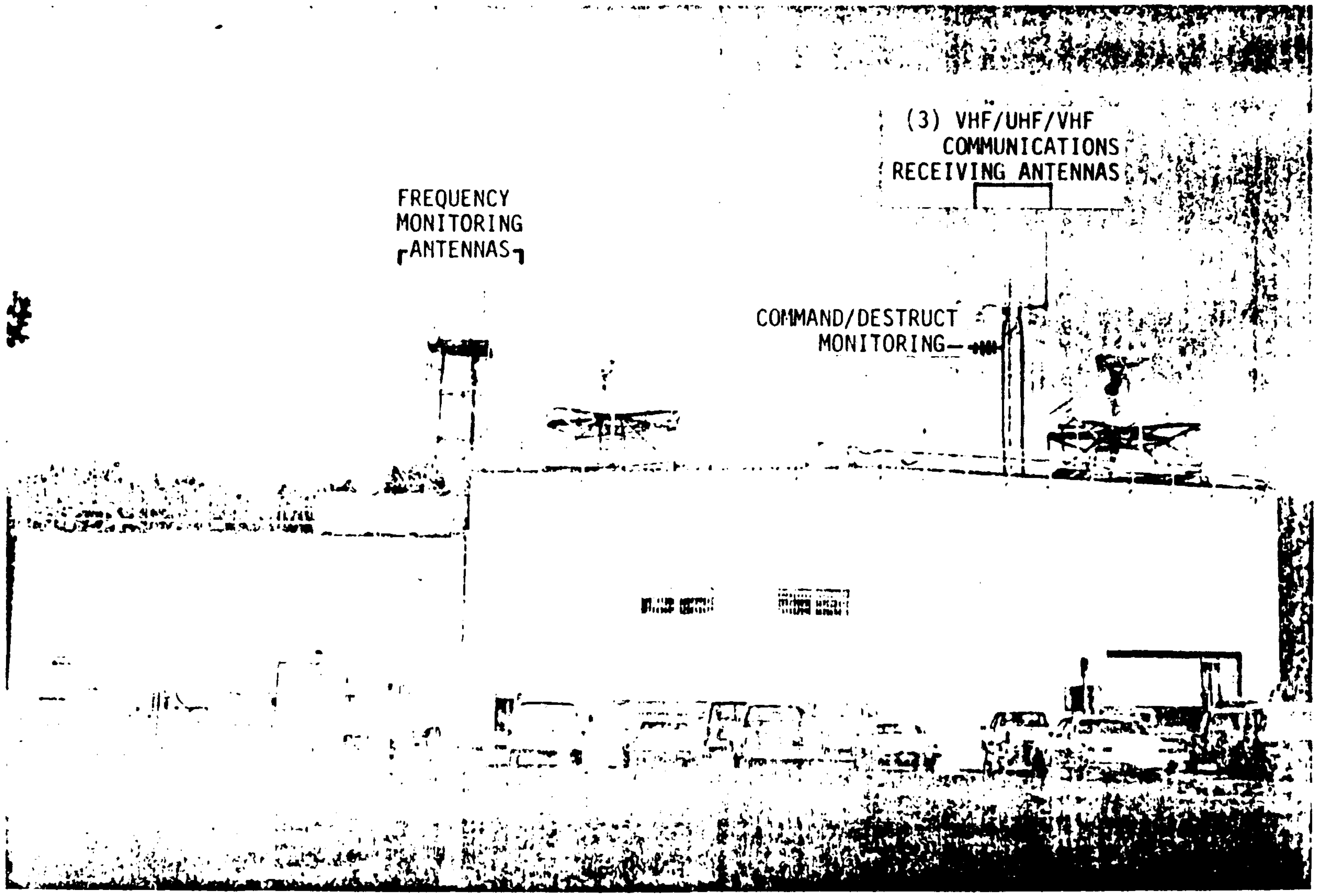


Figure 1-1. Telecommunications Building
(Bldg. N-162) With Antenna Arrays

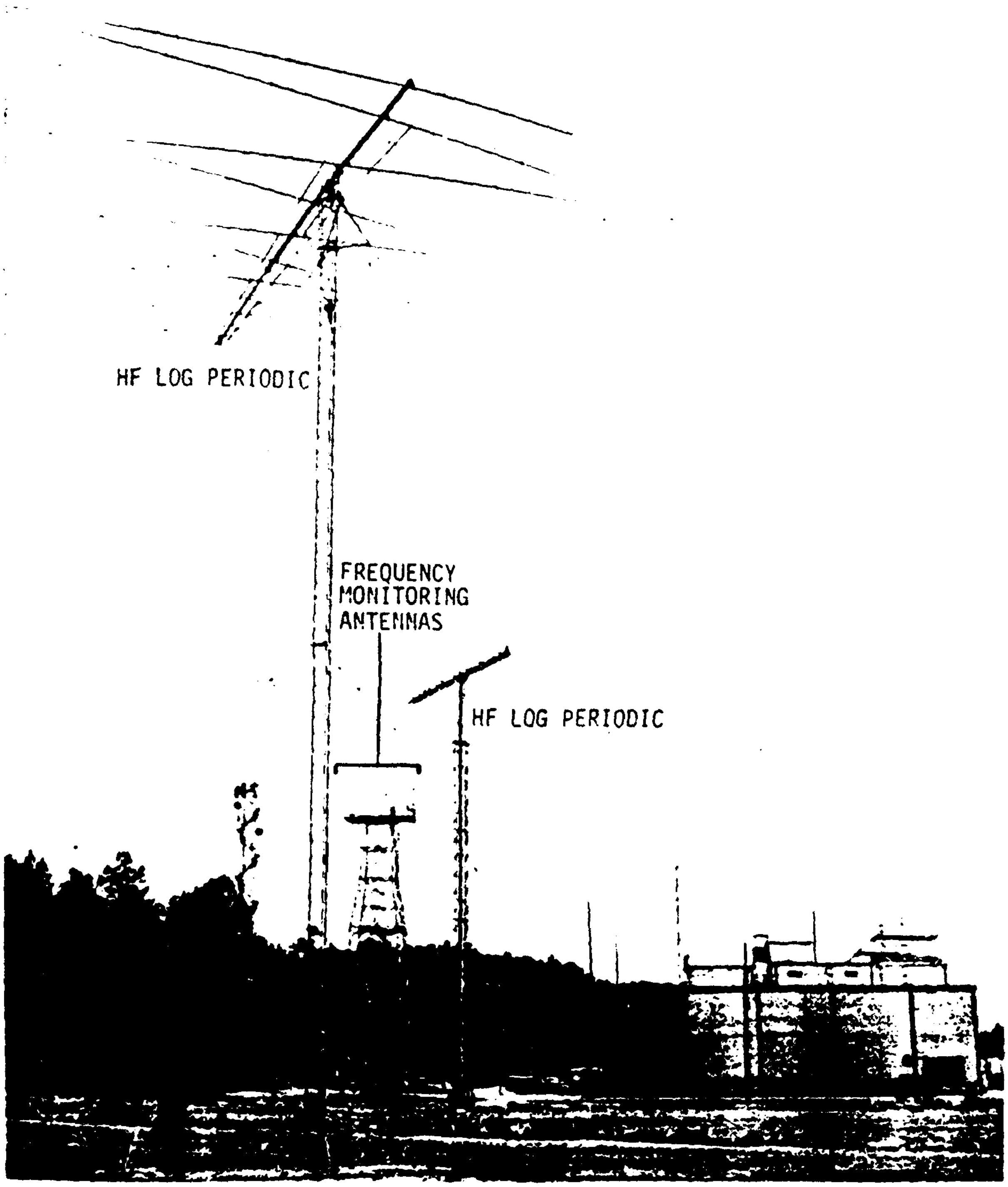


Figure 1-2. Communications Receiver Facility
(Bldg. N-162) Antennas

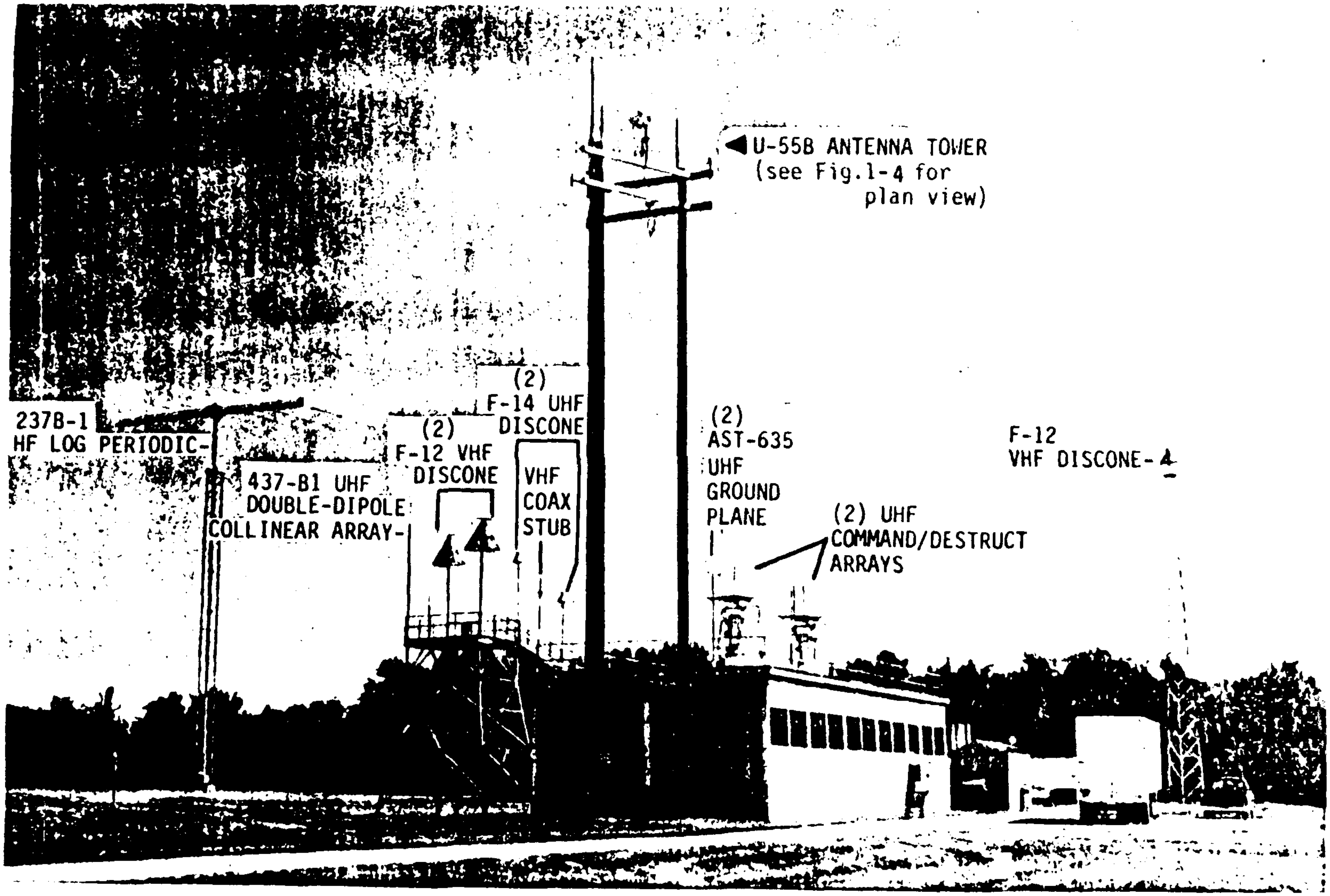


Figure 1-3. Communications Transmitter Building (U-55) & Associated Communications Antennas

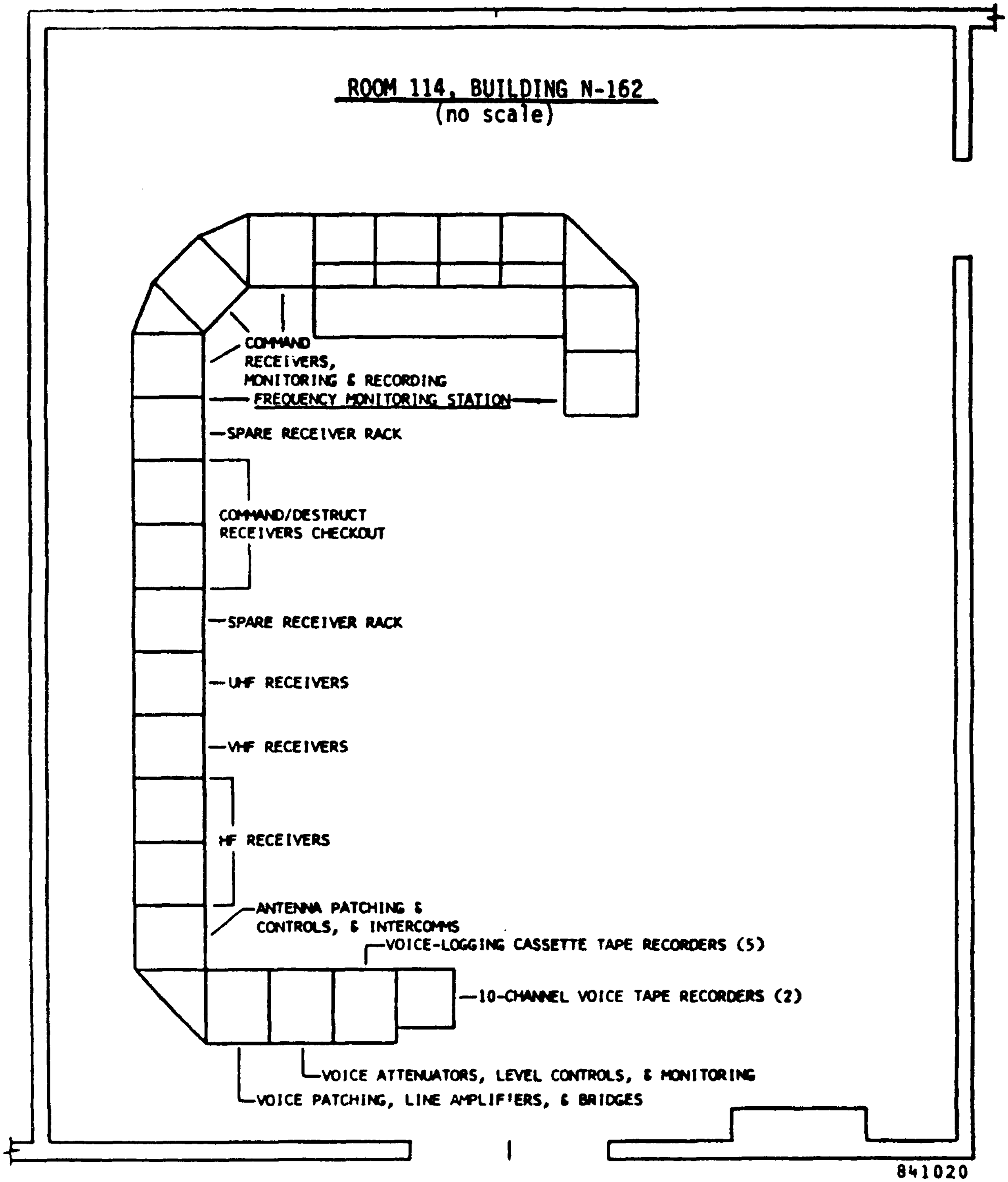


Figure 2-15. Communications Receiver Facility Equipment Location Plan

Reference Source: Instrumentation Handbook Volume IV, Communications Facilities and Systems, NASA/WFF, August 1979.

C.6 WJ-8718 HF RECEIVER, WATKINS, JOHNSON CO.

The WJ-8718 HF receiver is designed to receive AM, FM, CW, USB, LSB, and ISB emissions over the frequency range of 5 kHz to 29.99999 MHz. The receiver provides manual control, with remote control and remote monitoring being optional. In the manual mode, operating parameters are selected by pressing appropriate push-button/indicators. The depressed button indicates the selection of the operator by the appearance of a brightly colored display behind the clear front surface. Seven digits composed of light emitting diodes (LED'S) indicate the tuned frequency to a resolution of 10 Hz. The large tuning knob and four tuning rate push-buttons provide frequency tuning capability.

Specifications:

Tuning Range:	5 kHz to 29.99999 MHz
Tuning Resolution:	10 Hz
Antenna Conducted Oscillator Radiation:	-87 dBm, maximum
Input Impedance:	50 ohms, unbalanced, nominal
IF Bandwidth (3 dB):	Standard: 0.3, 1, 3.2, 6 and 16 kHz
Detection Modes:	Standard: AM, FM, CW Optional: LSB, USB, ISB
Frequency Display:	7 digit LED's
Frequency Resolution/ Readout:	10 Hz
Frequency Stability:	6 x 10^{-8} per day, 2 x 10^{-6} per year
Frequency Control:	Manual or Remote options

Synthesizer Lock-Up Time:	3 ms, typical; 10 ms, maximum
Synthesized BFO:	455 kHz ±8.9 kHz in 100 Hz steps
IF Rejection:	Greater than 90 dB
Image Rejection:	Greater than 90 dB
Audio Distortion:	Less than 5% at rated audio output
Audio Frequency Response:	±1.5 dB from 100 Hz to 8 kHz, 1 kHz reference frequency
Final IF Output:	20 millivolts, minimum, into 50 ohms for input signals greater than 3.0 microvolts
Sensitivity:	
300 kHz Bandwidth:	AM: 4 microvolt input, modulated 50% produces 11 dB S+N/N, minimum FM: 4 microvolt input, modulated at 1 kHz with 100 kHz deviation, produces 21 dB S+N/N, minimum
20 kHz Bandwidth:	AM: 2 microvolt input, modulated 50%, produces 17 dB S+N/N, minimum FM: 2 microvolt input, modulated at 1 kHz with 7 kHz deviation, produces 20 dB S+N/N, minimum
Audio Output Power:	100 milliwatts, minimum
Audio Response:	100 Hz to 40 kHz at 3 dB points
Video Output:	5 volts rms across 10 K-ohm unbalanced load
Video Response:	50 Hz to 500 kHz at 3 dB points
Signal Monitor Output:	21.4 MHz center frequency IF signal output
Output Stability With AGC:	FM: Output varies less than 2 dB AM: Output varies less than 15 dB
BFO:	21.4 MHz center frequency, variable ±20 kHz
Power Input:	115 VAC, 50-400 Hz

Power Consumption:	40 watts, maximum
Weight:	8.4 kg (18.5 lbs)
Size:	48 x 9 x 39.4 cm (19 x 3-1/2 x 15-1/2 inch)
Reference Source:	Instrumentation Handbook Volume IV, Communications Facilities and Systems, NASA/WFF, August 1979.

C.7 SR-209/AFC TUNABLE VHF/UHF RECEIVER, APPLIED COMMUNICATIONS

The SR-209/AFC performs the requirement for general HF/UHF/VHF communications receiver applications. It is completely solid state and features plug-in modules and printed circuit assemblies for the highest degree of versatility. Plug-in modules are available in electronic swept heads covering 30 to 1000 MHz, in tuning heads covering 2 to 12,000 MHz, in signal units for panoramic and signal analysis, in a frequency readout to display tuned frequency and in a battery pack which will supply power for field and emergency operation.

Characteristics are:

Frequency Tuning Range:	
Tuning Heads:	20 to 12,000 MHz
Electronic Swept Heads:	30 to 1000 MHz
Type of Reception:	FM, AM, CW and PAM (pulse)
IF Frequency:	21.4 MHz
Input Impedance:	50 ohms nominal, unbalanced to ground
Stability:	
AM:	Better than 6 dB from rated AM sensitivity (10 dB S+N/N) to -23 dBm

Reference Source: Instruction Manual for WJ-8733 Receiver and Instruction Manual for DRO-333A Frequency Counter, Watkins-Johnson Company

C.10 BCR-55 UHF RECEIVER AND BCD-29 AUDIO FREQUENCY DECODER, BABCOCK ELECTRONICS CORPORATION

The Receiver, Radio BCR-55 is a monitoring receiver for UHF FM radio control signals in the frequency range of 406 to 549.5 megacycles having carrier deviation up to $\pm$300 kilocycles. The BCR-55 provides indications of modulation deviation, signal level, and center frequency error for received signals. Detected audio signals are available for application to external decoding and monitoring equipment.

The Receiver, Radio BCR-55 contains an RF assembly, an IF assembly, and a power supply and audio assembly.

The RF assembly receives the RF carrier signal having a level of 5 to 100,000 microvolts at the input receptacle and passes it through the attenuators into an amplifier and mixer. The RF signal heterodynes in the mixer with another signal from the local crystal-controlled oscillator. The resultant IF signal from the mixer is fed to the IF assembly. A built-in noise generator provides a signal source for tuning purposes. A meter selector switch and meter provide monitor and tuning indications. The IF assembly provides amplification, limiting, and detection for the received signal. The demodulated signal from the discriminator is coupled into the audio assembly. Two additional signals from the first and second limiter circuits are also used in the audio assembly. After the carrier signal is demodulated, it is coupled to the audio assembly where the audio signals are amplified and appear at three audio output receptacles. The monitor circuits use differential amplifiers and meters to measure and indicate, on the front panel, the parameters mentioned above. A relay circuit detects the presence or absence of a carrier signal at the input receptacle and indicates this condition with lights on the front panel. The power supply circuits consist of two regulated +28 volts dc supplies, one 12.6 volts ac supply, one 6.3 volts ac supply, and one regulated +108 volts dc supply. The inputs of all of these power supply circuits are to a common primary input.

The BCD-29 Audio Frequency Decoder is used with the BCR-55 receiver.

The Decoder, Audio Frequency BCD-29 20-channel, audio frequency decoder. The BCD-29 will decode 20 standard IRIG channels with a minimum input of 0.125 VRMS for operation of six channels simultaneously. Front panel indicator lamps indicate which of the 20 channels are active and which inactive. In addition, relay connections indicating the active and inactive audio channels are available for external connection to remote indicating or control equipment.

The Decoder, Audio Frequency BCD-29 contains a power supply, an audio amplifier, and AGC circuit, 20 decoder channels, and channel indicator lamps.

The power supply operates on 115 volts ac, producing the following output voltages: +200 volts dc, 6.3 volts ac, -22 volts dc, and +28 volts dc.

The audio amplifier and AGC circuit amplifies the input audio command signal and maintains the constant output level necessary for the decoder channels.

The 20 decoder channels consist of the following: a filter, tuned to the desired frequency; a relay amplifier for energizing or de-energizing an internal control relay; an internal control relay which controls indicator lamps and an external control relay for that channel; and the external control relay which provides externally available relay contacts. Each channel filter is tuned to a different frequency, providing for the selection of the 20 IRIG channels. If the proper audio signal is present, the filter for that frequency will detect it, causing the corresponding relay amplifier to conduct, thus energizing the internal control relay. The internal control relay will, in turn, operate the ON indicator lamp for that channel and also energize the external control relay. The external control relay will provide the external contact closures for remote indicating or control equipment. All channels will normally be de-energized when a command is not present, and therefore indicate an OFF condition until the proper command signals are present. Recording is normally by an oscillograph.

The BCR-55 Receiver and BCD-29 Audio Frequency Decoder are rock mounted. Specifications for the BCR-55 Receiver and BCD-29 Audio Frequency Decoder are:

BCR-55 Receiver

Physical

Dimensions:

Length:	23-27/32 inches
Width:	19 inches
Height:	12-7/32 inches
Weight:	80 pounds

Electrical

Input Power:

Voltage:	103 to 126 VAC
Frequency:	55 to 65 cps
Total Power Consumption:	250 watts

RF Assembly:

Sensitivity:	5 to 100,000 microvolts
Frequency Modulation:	To ±300 kilocycles
Frequency Range:	406 to 549.5 megacycles
Frequency Stability:	±0.005 percent
Preset RF Frequencies:	Six (selected from plug-in crystals)
Image Response:	60 dB less than desired signal

IF Frequency:	33.5 megacycles
Audio Output Frequency Range:	0.300-100 kc ±3 db
Output Impedance:	2 outputs nominal 500 ohms 1 output nominal 50 ohms

BCD-29 Audio Frequency Decoder

Physical

Dimensions:

Length:	22-3/4 inches
Width:	19 inches
Height:	8-3/4 inches
Weight:	60 pounds

Electrical

Decoder Channel Frequencies:

Channel 1:	7,500 cps ±1%
Channel 2:	8,460 cps ±1%
Channel 3:	9,540 cps ±1%
Channel 4:	10,760 cps ±1%
Channel 5:	12,140 cps ±1%
Channel 6:	13,700 cps ±1%
Channel 7:	15,450 cps ±1%
Channel 8:	17,430 cps ±1%
Channel 9:	19,660 cps ±1%
Channel 10:	22,170 cps ±1%
Channel 11:	25,010 cps ±1%
Channel 12:	28,210 cps ±1%
Channel 13:	31,830 cps ±1%
Channel 14:	35,900 cps ±1%
Channel 15:	40,490 cps ±1%
Channel 16:	45,680 cps ±1%
Channel 17:	51,520 cps ±1%
Channel 18:	58,120 cps ±1%
Channel 19:	65,560 cps ±1%
Channel 20:	73,950 cps ±1%

Decoder Channel Indicator Lamps: 20 red colored lamps indicate inactive channels and 20 green colored lamps indicate active channels.

Externally Available Relay Contacts:	20 DPDT relay contact connections, each capable of conducting 2 amperes at 28 volts dc, resistive, are available at the rear panel connector.
Input Audio Sensitivity:	.125 volts rms for 6 channel operation.
Input Power:	
Voltage Limits:	102 to 126 VAC
Frequency Limits:	55 to 65 cps
Power Consumption:	150 watts
Input Impedance:	5,000 ohms (approx.)
Reference Source:	Handbook of Operation and Maintenance Instruction for Receiver Radio BCR-55, BEC RPT-1092, July 1, 1962, Babcock Electronics Corp. and Handbook of Operation and Maintenance Instructions for Decoder Audio Frequency BCD-24, BEC-RPT 1082, July 1, 1962, Babcock Electronics Corp.

C.11 RS-111-1B-12B RECEIVING SYSTEM, COLLINS RADIO CO.

The receiving system provides AM, FM and CW reception over the 30-1000 MHz frequency range in four bands. A built-in signal monitor provides a visual display of signal activity over a frequency range of up to 1.5 MHz on both sides of the tuned frequency. The sweep width of the display is continuously variable by means of a front-panel control up to 3-MHz maximum dispersion.

Specifications for this receiver are:

Type of Reception:	AM, FM, CW
Frequency Range:	30-1000 MHz in four bands: Band A, 30-60 MHz, Band B, 60-300 MHz, Band C, 235-500 MHz, Band D, 490-1000 MHz

Input Impedance:	To operate from 50-ohm source
Noise Figure:	Band A, 4 dB max; Band B, 6.5 dB max. Band C, 10 dB max; Band D, 12 dB max.
Image Rejection:	Band A, 60 dB min; Band B, 47 dB min. Band C, 65 dB min; Band D, 75 dB min.
IF Rejection:	Band A, 54 dB min; Band B, 80 dB min. Band C, 80 dB min; Band D, 90 dB min.
IF Bandwidths:	Four total, two operating simultaneously; 2 MHz and either 20 kHz, or 300 kHz selectable from front panel
Band A and B Output Stability:	AM: Output varies less than 3 dB for input range of 2 to 10,000 microvolt
	FM: Output varies less than 2 dB for input range of 1.5 to 10,000 microvolt
2 MHz Bandwidth:	AM: Output varies less than 4 dB for input range of 4 to 10,000 microvolt
	FM: Output varies less than 4 dB for input range of 4 to 10,000 microvolt
Band C and D Output Stability: 20/75/300-kHz Bandwidths	AM: Output varies less than 4 dB for input range of 4 to 10,000 microvolt
	FM: Output varies less than 2 dB for input range of 3 to 10,000 microvolt
2 MHz Bandwidth:	AM: Output varies less than 4 dB for input range of 8 to 10,000 microvolt

	FM: Output varies less than 4 dB for input range of 8 to 10,000 microvolt
Power Input:	115/230 VAC, ±10%, 48-420 Hz
Power Consumption:	51 watts, approximately
Weight:	35 lbs. approximately
Size:	5.25 inches high, 19 inches wide, 15.5 inches deep
Reference Source:	Instruction Manual for Type RS-111-1B-12B Receiving System, M/200/10/-75/GH, Watkins Johnson Company

C.12 901 RECEIVER, COMMUNICATIONS ELECTRONICS, INC.

The type 901 Receiver is an FM-AM-CW superheterodyne receiver covering the frequency range 30 to 300 MHz in two bands, 30-60 MHz and 600-300 MHz. The receiver uses single conversion to a 21.4 MHz IF. The IF bandwidth can be set to either 20 kHz or 300 kHz. The input impedance is suitable for a 50-ohm source. The audio output impedance is 600 ohms. The video output impedance is suitable for a 10 K-ohm, unbalanced load.

Specifications for the 901 Receiver are:

Type of Reception:	AM-FM-CW
Frequency Range:	30-300 MHz in two bands Low-band: 30-60 MHz High-band: 60-300 MHz
Inputs:	Two BNC type connectors, one with coaxial switch, permitting operation across full frequency range with single antenna or operation with separate antennas for each band
Input Impedance:	Suitable for 50-ohm source

Noise Figure:	Low band: 4 dB, maximum High band: 6.5 dB maximum
Image Rejection:	Low band: 60 dB, minimum High band: 50 dB, minimum
IF Frequency:	21.4 MHz
IF Bandwidths:	300 kHz or 20 kHz, selectable from front panel
IF Rejection:	Low band: above 40 MHz, 75 dB, minimum below 40 MHz, 54 dB, minimum High band: greater than 100 dB
Oscillator to Antenna Conduction:	Low band: 15 microvolts, maximum High band: below 260 MHz, 15 microvolts, maximum above 260 MHz, 25 microvolts, maximum
Reference Source:	Instrumentation Handbook Volume IV, Communications Facilities and Systems, NASA/WFF, August 1979.

C.13 WJ-8617B VHF/UHF RECEIVER, WATKINS-JOHNSON COMPANY

The WJ-8617B VHF/UHF Receiver is a fully synthesized, digitally controlled receiver, designed to operate in the VHF/UHF frequency range. It receives AM, FM, CW and Pulse emissions over a frequency range of 20 to 500 MHz. The standard receiver is capable of manual operation, utilizing the front panel controls and automatic operation, utilizing the built-in microprocessor and 16 channel memory. Remote control capabilities can also be incorporated, utilizing an optional IEEE-488 bus or RS-232 interface. During the manual operating mode, all receiver functions are controlled by the front panel controls. The operating parameters are selected by depressing the appropriate front panel pushbuttons. When depressed, an illuminated LED on the buttons indicate the selection.

Specifications are:

Frequency Range:	20-500 MHz (20-1100 MHz optional)
Detection Modes:	AM, FM, CW, and PULSE standard. SSB and LOG optional
Tuning Scheme:	Frequency synthesized local oscillators locked to internal reference
Phase Noise:	95 dBc/Hz, 10 kHz away from carrier typical
Reference Accuracy:	1 part in 10-7 or external 1 MHz
Tuning Resolution:	100 Hz
Synthesizer Tuning Speed:	10 msec maximum, 3 msec typical
Input Impedance:	50 ohm nominal
Input VSWR:	2.5:1, 20 - 300 MHz 3.0:1, 300 - 1100 MHz
Noise Figure:	11 dB, maximum
Third Order Intercept Point:	+8 dBm typical; +3 dBm, minimum (20 - 500 kHz)
Second Order Intercept Point:	+50 dBm, minimum
Preselection:	Automatically switched, suboctave bandpass filters
LO Radiation:	-90 dBm maximum
Image Rejection:	90 dB minimum
IF Rejection:	90 dB minimum
Internal Spurious:	Equivalent to -115 dBm maximum at the RF input
Reciprocal Mixing:	With an input signal at a rated sensitivity level; an out-of-band signal removed seven times the 50 kHz IF bandwidth, at a level 70 dB above rated sensitivity, will not degrade the desired output signal ratio (S+N)/N by more than 3 dB.

IF Bandwidths: 5 IF bandwidth capability. Standard available bandwidths, shape factor, and rated sensitivity are as follows on Table 1:

Table 1 - Available Bandwidths and Rated Sensitivity

Bandwidth kHz	Shape Factor (min)	Sensitivity (dBm)
3.2	3.0:1	-109
6.4	3.0:1	-106
10	3.0:1	-104
15	3.0:1	-103
20	3.0:1	-101
25	3.0:1	-100
30	3.0:1	-100
50	3.0:1	-97
75	3.0:1	-95
100	3.0:1	-94
250	4.0:1	-90
300	4.0:1	-89
500	4.0:1	-87
1,000	4.0:1	-84
2,000	4.0:1	-81
4,000	4.0:1	-78
6,000	N/A	-76
8,000	N/A	-75

Final IF: 21.4 MHz

AM Stability: 6 dB maximum from AGC threshold to a level 100 dB above AGC threshold (-50 dBm maximum CW input)

Switched Video Output: 1 Volt peak-to-peak, nominal, into 91 ohm load for FM Signals with a peak deviation at 30% of the IF bandwidth and AM with 50% modulation. DC coupled for FM and AM.

IF Outputs:

Switched IF Output: -30 ± 3 dBm at rated sensitivity level

Wideband IF Output: 20 dB above RF input minimum

Wideband IF Output (optional):	-30 ±3 dBm, minimum, with a -76 dBm RF input. Minimum bandwidth of 4 MHz (6 MHz BW optional).
FM Monitor:	DC coupled FM output, 1 volt peak-to-peak minimum, into 91 ohms, with peak deviation equal 30% of to the selected IF bandwidth
Video Amplifier Frequency Response:	DC to 1/2 IF bandwidth for FM monitor; DC to 1/2 IF bandwidth for AM/FM Switched Video Output
Audio Output:	10 mW, with less than 5% harmonic distortion, into 600 ohms for 50% AM or FM peak frequency deviation equivalent to 30% of the IF bandwidth
COR/Squelch:	Adjustable from noise level to approximately 40 dB above noise. COR provides 100 mA current sink-to-ground for switching; +24 Vdc maximum external voltage
Signal Monitor: (optional)	
Sweep Width:	0-4 MHz continuously adjustable
Resolution:	10 kHz
Sweep Rate:	Adjustable from 15 to 25 Hz
Marker:	Center frequency (locked to receiver frequency standard)
Display Lin/Log:	
CRT:	1 x 3 inches nominal dimensions
PAN:	Provides pan display during Scan/-Step modes with optional Digitally Refreshed Display
Power Requirement:	110, 120, 220, 240 VAC; 47-400 Hz; 100 watts
Dimensions:	19-inch rack mount, 18-inch depth (excluding connectors and handles), and 5.25 inch panel height

Weight:	50 pounds, approximately
Reference Source:	Information Manual for Type WJ-8617B VHF/UHF Receiver, 7/83, Watkins-Johnson Company

C.14 MSR 904A MICROWAVE RECEIVER WITH FCS-904 FREQUENCY COUNTER SYNTHESIZER, MICRO TEL CORP.

The MSR-904A Microwave Receiver is a compact heterodyne receiver with overall frequency coverage from 0.50 to 18.0 GHz in its standard form, with fundamental mixing. The FCS-904 Frequency Counter/Synthesizer is an accessory device which allows precise digital control of frequency when operating with the MSR-904A Receiver. Together the synthesizer and MSR-904A form a precise microwave system with accurate frequency control and exceptional stability and spectral purity.

MSR 904A Specifications:

RF Section:

Frequency Coverage:	0.5-18 GHz
RF Bands:	.5-2, 2-4, 4-8, 8-12, 12-18 GHz, .5-18, 18-26.5, 26.5-40 GHz
Frequency Indicator:	5 digit LED display indicates true RF center frequency to an accuracy of 1% $\pm$1 count, in the "CW" mode. Displays marker frequency in "BAND" or "F1-F2" mode, according to F1/F2-/F0 push-button selection.
Band Overlap:	10 MHz minimum
First Image Rejection:	0.5-12 GHz, 70 dB minimum 12-18 GHz, 65 dB minimum
Preselection:	.5-18 GHz automatically tracked in all tuning modes.
RF Input Impedance:	50 ohms nominal, unbalanced to ground.

Noise Figure (dB):	20 dB typical, 23 dB maximum
Residual FM:	

RF Band:	Max Residual FM:
.03-4.0 GHz:	20 kHz p-p
4.0-8.0 GHz:	40 kHz p-p
8.0-12.0 GHz:	75 kHz p-p
12-18 GHz:	100 kHz p-p

Frequency Stability (Short Term)	1 part in 10^{-5} of RF, maximum, drift per second. With 5 minute warm-up, at 25°C ambient
(Long Term)	5 parts in 10^{-5} of RF, maximum, drift per 3 minute interval. After 30 minute warm-up at 25°C ambient, at fixed RF frequency
Frequency Pulling:	1 part in 10^{-5} of RF, maximum with either (a) input VSWR change from 1.0 to (b) in-band Rf signal of -20 dBm.

250 MHz IF OUTPUT

Bandwidth at 3 dB:	28 MHz minimum, limited only by the YIG preselector.
IF Gain from First Mixer:	20 $\pm$3 dB, with IF GAIN at maximum setting, IF attenuator set for 0 dB.
1 dB Compression Point:	-10 dBm minimum
Impedance:	50 ohms nominal, unbalanced to ground

21.4 MHz IF OUTPUT

Bandwidth at 3 dB:	8 MHz, nominal
Output Level:	Gain is automatically controlled to provide an output level of -20 $\pm$2 dBm for an input level of 0 dBm; output reduces by 5 dB maximum when input is reached by 50 dB

IF SELECTIVITY AND IMAGE

IF Selectivity:	1) 100 ±10 kHz @ - 3 dB
	2) 1.0 ±0.2 MHz @ -3 dB
	3) 5.0 MHz ± 1 MHz at -3 dB
	4) 30 MHz ± 2 MHz at -3 dB
Image Rejection:	Second IF images, and all subsequent IF images, are at least 50 dB down

AM VIDEO OUTPUT

Linear or logarithmic video output is available at the rear panel; selection is made at the front panel.

Output Impedance:	50 ohm unbalanced to ground
Amplitude:	0.2 to 4.0V maximum, unloaded
Baseband:	One half the selected IF bandwidth, DC coupled
Video Filter:	Switchable from the front panel; reduces baseband to 50 kHz in all IF bandwidths
Logarithmic Range:	70 dB minimum
Logarithmic Accuracy:	±2 dB
Linear Gain Control:	60 dB minimum, front panel controllable

FM VIDEO OUTPUT

Output Impedance:	50 ohm unbalanced to ground
Amplitude:	2.0 VPP minimum, unloaded, with input at -40 dB and frequency deviation of ±0.5 times selected IF bandwidth
Baseband:	Dc to 0.5 times selected IF bandwidth, minimum
AM Rejection:	20 dB minimum

SPURIOUS AND RESIDUAL RESPONSES

Spurious:	1) Due to out-of-band signals above 0.5 GHz: 5 dB rejection, minimum.
	2) Due to out-of-band signals below 0.5 GHz (including all IF frequencies): 70 dB rejection, minimum.
	3) Due to two in-band signals, spaced by 10 MHz, with amplitudes of -30 dBm: all inter-mod products are at least 20 dB down, with IF GAIN adjusted for no larger than full scale display at AM VIDEO output.
Residual:	With 50 ohm termination of ANTENNA input, internally generated residual responses do not exceed -90 dBm equivalent input, at any RF frequency.

AUDIO OUTPUT (at phone jack)

Output Level:	$\pm$0.40V maximum output capability into 600 ohms unbalanced load, without clipping.
Sensitivity:	With passive 50 ohm termination on ANTENNA jack, audio noise level at all RF frequencies is 0.1 milliwatts minimum into 600 ohm load in all signal modulation modes, with IF GAIN and AUDIO GAIN maximum.
Response:	$\pm$3 dB, 250 Hz to 10 kHz

DRIVE CIRCUITRY FOR PANORAMIC DISPLAY

Sweep Widths:	BAND mode: Fixed sweep of the entire width of the RF band selected.
	F1-F2 Mode: Fixed sweep of the entire range selected.

	FO mode: Sweep width variable from 0 to ±15% of width of RF band selected. Calibration accuracy ±20% or better.
	MAN mode: Same width as VAR-SCAN mode, but sweep mode is manual.
Display Shift:	In FO mode, shift of center frequency of display is less than 1% of width of RF band selected, as sweep width is varied from maximum to minimum.
Sweep Rate:	In BAND, F1-F2 and FO modes, variable over the range of 0.1 Hz or less to 30 Hz or greater.
Horizontal Output:	±5 volts dc coupled and centered at 0 volts dc, with 2000 ohms minimum load impedance. Sweep amplitude is independent of actual frequency range swept. Positive-going sweep voltage (negative going flyback) corresponds to increasing RF frequency on all RF bands.
Horizontal Linearity:	5% maximum
RF Marker:	In BAND and F1-F2 modes, negative marker pulse of 0.1 volts amplitude and 0.5 millisecond nominal duration is added to the vertical output signal.
Blanking:	+10 volt retrace blanking pulse is applied in BAND, F1-F2 and FO modes.

POWER SOURCE SPECIFICATIONS

Line Frequency:	50-400 Hz
Line Voltage:	115 or 230 volts, switch selectable
Period of Operation:	Indefinite
Power Consumption:	120 watts nominal

WEIGHT

Total receiver weight is
45 pounds.

FCS-904 Frequency Counter Synthesizer Specifications:

Frequency Range:	30 MHz-18 GHz
Resolution:	10 kHz standard
	5 MHz REF OSC Stability:
	3x10-9/24 Hr. Long-term stability
	3x10-10/Sec. Short-term stability
Phase Noise:	70 dBc at 10 kHz removed from the carrier in a 1 Hz bandwidth
Incidental FM:	100 Hz rms
Switching Time (Maximum):	
	50 ms: Typically less than 5 ms when a band change is not required.
Display:	16 character-16 segment alpha numeric display
Tuning:	Keyboard IEEE-488 Interface Optical Encoder
Size:	3 1/2 x 17 x 19 1/2 inches
Weight:	32 pounds
Reference Source:	Operating and Maintenance Manual for MSR - 904A Microwave Receiver, May 1984, and Operating and Maintenance Manual for FCS-904 Frequency Counter Synthesizer, June 1983, MICRO-TEL Corporation.

0.5 5-124A RECORDING OSCILLOGRAPH, CONSOLIDATED ELECTRODYNAMICS CORP.

The recording oscillograph is an instrument capable of making a record of any dynamic phenomenon which is convertible to an analog voltage. Sensing of these phenomena is usually accomplished with low voltage output transducers, which translate mechanical variations into electrical impulses. Electrical impulses produced by the transducers may be fed into an amplifier or bridge balance where the signal is conditioned before being introduced into the oscillograph. Light from a mercury arc lamp is reflected by the galvanometer mirror through a simple optical system which produces a spot of light on a moving strip of photographic material. By using various combinations of light intensity and record speed, clear legible records are obtainable over a wide range of applications.

Characteristics of this recording oscillograph are:

Recording Channels:

Trace Capacity:	18 active data channels
Galvanometers:	CEC Series 7
Frequency Response:	300 Hz to 13 kHz
Trace Identification:	Sequential trace interruption

Paper Transport System:

Paper Transport Speeds:	0.635, 2.54, 10.2, 40.64, 163 cm (0.25, 1, 4, 16 and 64") per second
Record Width:	17.8 cm (7") paper, full width recording capability
Record Length:	7.6 cm (3") diameter supply roll, max; 61 meters (200 ft) thin base paper, max

Recording Paper:	DATA FLASH 54, 55 and 46 and all other CEC approved direct-print type papers
<u>Optical System</u>:	
Galvanometer Light Source:	Mercury arc lamp compatible with printout paper in spectral output and intensity
Galvanometer Light Intensity:	Control of front panel
Optical Arm:	29.2 cm (11.5") at zero deflection
Writing Speed:	1270 mps (50,000 ips) attainable using CED approved printout paper
Trace Width:	0.03 cm (0.012") minimum static trace
Grid Lines:	0.254 cm (1/10") and metric
<u>Front Panel Controls:</u>	
Power:	Main Power ON-OFF Switch
Drive Motor:	ON-OFF push-button switch
Record Speed Selection:	0.25, 1, 4, 16 and 64 IPS are selectable by push-button switches
Lamp Intensity Control:	Continuously variable intensity control knob
Paper Supply Indicator:	9, 1/4, 1/2, 3/4 and FULL indicator
Remote Operation:	Remote control receptacle connector attached to instrument and mating connector supplied for remote operation of drive motor.
Electrical:	Operates from a 105-132 VAC, 50/60 Hz source. Maximum of 500 watts required.
Physical:	
Height:	19.4 cm (7-5/8") including rubber feet

Width:	33 cm (13")
Length:	39.4 cm (15-1/2") including controls
Weight:	18 kg (40 lbs), not including paper or accessories
Reference Source:	Operations and Maintenance Manual, Type 5-124A Recording Oscillograph, 992169-0012, Consolidated Electrodynamics Corporation.

Oscillator Frequencies:	
1st Local Oscillator:	735 kHz ±1/2 sweep width
2nd Local Oscillator:	320 kHz
Sensitivity:	5 mv input at 500 kHz produces at least one-inch deflection on the CRT
Gain Control Range:	60 dB, minimum
Crystal Marker:	
Frequency:	500 kHz
Tolerance:	.01%
Crystal Marker Radiation:	The radiation of the crystal marker oscillator through the input connector is not more than 10 mv
Size:	9 cm (3-1/2")H x 48 cm (19")W x 38 cm (15")D
Weight:	Approximately 8.2 kg (18 lbs)
Reference Source:	Instrumentation Handbook, Volume IV Communications Facilities and Systems, NASA/WFF, August 1979.

F.8 SM-9310B SIGNAL MONITOR, COMMUNICATIONS ELECTRONICS, INC.

The SM-9310B Signal Monitor is used with an appropriate receiver to provide a visual display of signals present about the frequency to which the receiver is tuned. Such a display is an aid in analyzing signals intercepted by the receiver, and can be used to determine such things as the amplitude and type of modulation of the signals. The signal monitor is designed for use with a receiver having an IF frequency of 21.4 MHz. The sensitivity of the unit is such that a 10-microvolt signal at the input will result in a one-inch vertical deflection of the signal trace of the screen of the CRT. Resolution is such that two signals 20 kHz apart appear on the screen as separate traces with a 6-dB valley between them.

Its technical characteristics are:

Number of Inputs:	One, BNC type
Input Impedance:	50 ohms
Input Center Frequency:	21.4 MHz
Sweepwidth:	0-3 MHz, continuously variable
Range of Center Frequency Control:	±200 kHz
Flatness of Response:	3 MHz ±2 dB
Resolution:	Using approximately 100 kHz sweepwidth, two signals 20 kHz apart will be displayed with at least a 6 dB valley between the peaks
Sensitivity:	10 mv input at 21.4 MHz produces at least one-inch deflection of signal trace
Sweep Rate:	30 ±6 Hz
First IF Frequency:	4.3 MHz
Second IF Frequency:	950 kHz
Image Rejection:	50 dB
IF Rejection:	70 dB
Power Input:	115 v, 50-400 Hz
Power Consumption:	17 w, approximately
Overall Dimensions:	9 cm (3.5")H, 48 cm (19")W, and 43 cm (16.9")D
Reference Source:	Instrumentation Handbook Volume IV Communications Facilities and Systems, NASA/WFF, August 1979.

Internal

Basic Frequency:	36495 360 Hz
Basic Frequency Drift:	+1 part in 10 per year (±36.5Hz per year)
Paper Speed:	0.663 inches per minute print 1.326 inches per minute feed out
Stylus Speed:	44.88 inches per second
Reference Source:	UPI Instruction Manual, UNIFAX II Newspaper Receiver, GOES Series, Volume 1, Undated

F.15 7580 TRANSFER OSCILLATOR, BECKMAN INSTRUMENTS, INC.

The Model 7580 Transfer Oscillator is designed to measure frequencies ranging from dc to 12,000 MHz. The instrument will accommodate several types of RF signals, including continuous fixed frequency signals with or without amplitude modulation, frequency-modulated signals and pulsed RF signals. All signals may contain considerable noise without affecting the ease or accuracy of measurement.

The transfer oscillator generates a fundamental frequency which may be varied within two ranges: from 7.5 to 15 MHz and from 75 to 150 MHz. It also generates all harmonics of this fundamental up to and beyond the 80th. To measure the frequency of an input signal, the fundamental is adjusted to the point where one of its harmonics has the same frequency as the input signal. This is done by beating the harmonic against the input signal and varying its frequency until the difference frequency as observed on a built-in oscilloscope, is zero. Then, a frequency equal to the fundamental divided by a power of 10 is fed to the counter. Now, if the counter counted each cycle of this signal for .01, 0.1 and/or 1 second the fundamental frequency would be displayed. To find the input frequency, then, we would multiply this indication by the harmonic number, N. To avoid this calculation, the counting period is expanded to N times the usual decimal period, with the result that the input frequency appears directly in decimal digits on the face of the counter.

Specifications for this transfer oscillator are:

Entire System (transfer oscillator plus frequency counter):

Frequency Measuring Range:	DC to 12,000 MHz
Type of Input Signal:	Continuous, fixed-frequency signals, FM signals, pulsed RF signals
Required Input Amplitude:	Never more than 100 mv rms
Transfer Oscillator:	
Frequency:	7.5-15 MHz and 75-150 MHz
Frequency Stability:	.001% per minute
Dial Calibration:	Increments of 1 kHz on 7.5-15 MHz range. Increments of 10 kHz on 75-150 MHz range
Accuracy of Dial Setting:	0.1% of fundamental frequency
Repeatability of Dial Setting:	.005%
Electrical Vernier:	Varies fundamental frequency approximately ±.015%
Harmonic Signal:	All harmonics through the 80th are usable
Signal to Counter:	Frequency: 0.75-1.5 MHz Amplitude: 1 volt rms Output Impedance: 1000 ohms
Beat Frequency Amplifier:	
Bandwidth:	1 kHz to 1 MHz
Output Signal:	1 volts rms out of 1000 ohms

Built-In Oscilloscope for Displaying Beat Frequency:	
Size:	5 cm (2") in diameter
Internal Sweep:	60 Hz sine wave with phase control
Power Requirements:	117 v ±10%, 50-60 Hz, 175 w
Dimensions:	22.2 cm (8-3/4")H, 48 cm (19")W, 46 cm (18")D
Reference Source:	Instrumentation Handbook Volume IV Communications Facilities and Systems, NASA/WFF, August 1979.

F.16 SPECTRUM ANALYZER 8555A RF AND 8552B, IF, HEWLETT-PACKARD

The analyzer RF and IF sections form a super-heterodyne receiver with spectrum scanning capabilities over the frequency range of 10 MHz to 40 GHz in 14 frequency bands. The analyzer presents a calibrated CRT display up to 2 GHz wide. Absolute calibration accuracy is maintained from 10 MHz to 18.0 GHz in 10 frequency bands, using internal mixing. The frequency range from 12.4 GHz to 40 GHz is covered in 4 frequency bands through the use of external mixers.

Specifications:	
Tuning Range:	
With Internal Mixer:	0.01 - 18.00 GHz
With External Mixer:	12.4 - 40 GHz
Frequency Accuracy:	
Dial Accuracy:	n x (±15 MHz) where n is the mixing mode
Scan Accuracy:	Frequency error between two points on the display is less than 1% of the indicated separation

Resolution:

Bandwidth Ranges:	IF bandwidths of 0.10 to 300 kHz provided in a 1.3 sequence
Bandwidth Accuracy:	Individual IF bandwidth 3 db points calibrated to ±20%
Frequency Range (GHz):	0.01 - 18 GHz with external waveguide mixer and appropriate waveguide tapers
Frequency Range:	12.4 - 40 GHz
Input Attenuator Range:	0-50 dB in 19 dB steps
Reference Source:	Instrumentation Handbook Volume IV Communications Facilities and Systems, NASA/WFF, August 1979.

APPENDIX L

NATIONAL TRAINING CENTER

FORT IRWIN, CALIFORNIA

SPECTRUM MANAGEMENT, ENGINEERING, AND CONTROL SYSTEM (SMECS)

FOR THE

U.S. ARMY
NATIONAL TRAINING CENTER
FT. IRWIN, CA.

SPONSORED BY:

USATRADOC, FT. MONROE, VA.
AND
USAISC, FT. HUACHUCA, AZ.

DEVELOPED BY:

THE ELECTROMAGNETIC COMPATIBILITY
ANALYSIS CENTER
ANNAPOLIS, MD.

SAS HARDWARE

1	HP 9826 DESK-TOP COMPUTER WITH 320 KBYTES OF MEMORY, 260 KBYTE FLEXIBLE DISK UNIT, CRT, AND IEEE-488 (HP-IB) INTERFACE
1	RS232C SERIAL INTERFACE
1	HP8566A SPECTRUM ANALYZER
1	EM SYSTEMS S3110 ANTENNA COMPLEX (200 kHz TO 18 GHz), WHICH INCLUDES: C1500Q ANTENNA CONTROLLER M1085 SIGNAL DISTRIBUTION UNIT A7310 (0.2-100 MHz) OMNI ANTENNA A6432 (0.1-2 GHz) OMNI ANTENNA A6472 (2-8 GHz) OMNI ANTENNA A6472 (8-18 GHz) OMNI ANTENNA A7102 (0.1-2 GHz) DIRECTIONAL ANTENNNA A5131 (2-18 GHz) DIRECTIONAL ANTENNA ASSEMBLY WITH A7130 FEED D1800 ROTATOR/PEDESTAL UNIT
1	HP8761A 0-18 GHz SWITCH
1	HP11713A SWITCH DRIVER

BACKGROUND

- NASA: EXTENSIVE HISTORY OF RF INTERFERENCE AND PHYSICAL INTERFERENCE AT FT. IRWIN, CA.
- ARMY: SOUGHT DEVELOPMENT OF THE NATIONAL TRAINING CENTER AT FT. IRWIN, CA.
- ECAC: ACTIVELY SUPPORTED INVESTIGATION COMMITTEE

DEVELOPMENT GOALS

- TO PROVIDE AUTOMATED SUPPORT FOR THE NATIONAL TRAINING CENTER SPECTRUM MANAGER
- TO PROVIDE REAL-TIME SPECTRUM MONITORING AND CONTROL OF NTC EXERCISES
- TO ENSURE THAT THE NASA GOLDSTONE DEEP-SPACE TRACKING FACILITY WILL EXPERIENCE NO INTERFERENCE FROM NTC

STAND-ALONE CAPABILITIES DESCRIPTION

PRE-EXERCISE SUPPORT

- FREQUENCY ASSIGNMENT MODEL

  ASSIGNS FREQUENCIES FROM THE FREQUENCY ASSIGNMENT FILE AND PREPARES ROTATION CEOI'S CONSIDERING UNIT/ OPERATIONS REQUIREMENTS.

- PRE-EXERCISE ANALYSIS OF INTERFERENCE POTENTIALS

POST-EXERCISE ANALYSIS

- HISTORY AND SUPPORTING ANALYSIS OF EXERCISE ACTIVIES

STAND-ALONE SPECTRUM MANAGEMENT FACILITY FUNCTIONAL DESCRIPTION

- FREQUENCY ASSIGNMENT FILES
- FRRS DATA BASE
- TOPOGRAPHIC DATA BASE
- PROPAGATION ANALYSIS MODELS
- NTC SPECTRUM USAGE DATA BASE (SPECTRUM ARCHIVE DATA)
- EQUIPMENT CHARACTERISTICS FILE
- REAL-TIME MONITOR SYSTEM SUPPORT
  - SPECTRUM ANALYZER SWEEP PARAMETERS (BANDTABLE FILE)
  - SPECTRUM SWEEP SEQUENCIES FILE
  - GOLDSTONE DSN MISSION FILE
  - EXPECTED SPECTRUM USAGE FILE
  - SPECTRUM ANALYZER TRACE REPLAY
  - ARCHIVE COMPRESSION

RTMF CAPABILITIES

THE RTMF PROVIDES THE NTC SPECTRUM MANAGEMENT OFFICE WITH THE CAPABILITY TO:

- MONITOR THE SPECTRUM FROM 200 kHz TO 18 GHz FROM TWO REMOTELY LOCATED SPECTRUM ANALYSIS SITES (SAS)
- COMMAND AND CONTROL THE OPERATION OF THE SAS SITES CONCURRENTLY YET INDEPENDENTLY
- RECORD AND MAINTAIN A RECORD OF THE SPECTRUM MONITORING ACTIVITIES
- DISPLAY THE RESULTS OF THE MONITORING ACTIVITY IN TERMS CORRELATED TO ASSIGNED, UNASSIGNED, HISTORICAL, AND NON-HISTORICAL FREQUENCIES
- DISPLAY AND PRINT OBSERVANCES OF SELECTED FREQUENCIES, IN SELECTED BANDS, OR OTHER FREQUENCIES OF SPECIAL INTEREST TO THE NTC
- MAINTAIN A LOG OF THE RTMF IMPORTANT EVENTS

REAL-TIME MONITORING FACILITY

OFF THE SHELF HARDWARE TECHNOLOGY

- MONITOR SITE: HP-8566A/HP-9826/ANTENNA ARRAY
- CONTROL SITE: PDP-11/44 BASED SYSTEM

SOFTWARE TECHNOLOGY-FULLY INTERGRATED DESIGN APPROACH

- SYSTEM ARCHITECTURE BASED ON NATIONAL SPECTRUM ALLOCATIONS
- SOFTWARE IMPROVEMENT OF HARDWARE ACCURACY: TEMPERATURE AND AGE COMPENSATING
- REAL-TIME CORRELATION TECHNIQUES
- FULL SWEEP SEQUENCE FLEXIBLE
- MAINTAINED FULL REMOTE MANUAL OPERATIONS

PRIMARY RTMF DISPLAYS

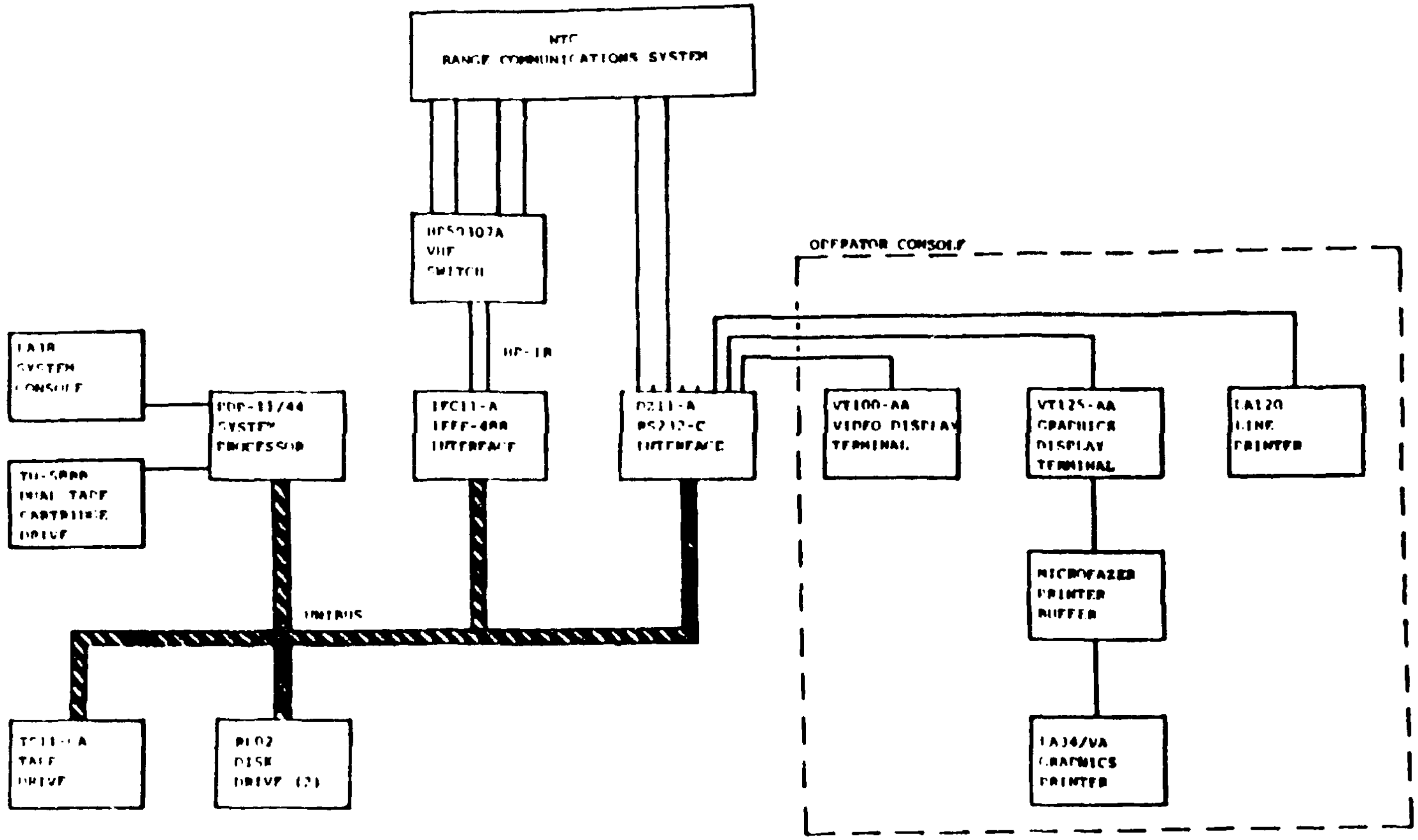
```
14:45  UNTIL AP    TIEFORT MT.                    | 14:45  UNTIL AP    GRANITE MT.
------------------------------------------------- | -------------------------------------------------
PROTECTS:  UNC   UN   UHC   UH   ANC   AHC        | PROTECTS:  UNC   UN   UHC   UH   ANC   AHC
BAND 1                                            | BAND 1
GOLDST. S   Ø    Ø     Ø    Ø     Ø     Ø         | GOLDST. S   Ø    Ø     Ø    Ø     Ø     Ø
BAND 2                                            | BAND 2
GOLDST. X   Ø    Ø     Ø    Ø     Ø     Ø         | GOLDST. X   Ø    Ø     Ø    Ø     Ø     Ø
BAND 3                                            | BAND 3
NTC LFX     Ø    Ø     Ø    Ø     Ø     Ø         | NTC LFX     Ø    Ø     Ø    Ø     Ø     Ø
BAND 4                                            | BAND 4
SPECIAL     2    Ø     Ø    Ø     2     Ø         | SPECIAL     Ø    Ø     2    1     Ø     2
------------------------------------------------- | -------------------------------------------------
ASSIGNMENT STATUS:   UN   UH   AN   AH            | ASSIGNMENT STATUS:   UN   UH   AN   AH
  (% OF TOTAL)       57   Ø    43   Ø             |   (% OF TOTAL)       Ø    57   Ø    43
------------------------------------------------- | -------------------------------------------------
  PFL:               CUM        NEW               |   PFL:               CUM        NEW
                      3          Ø                |                       3          Ø
---------------------------------------------------------------------------------------------------
DISPLAY:   T=   275   468   506   275                           G=   352   469   508   352
PROTECT:          4     4     4     4                                  4     4     4     4

TIEFORT   L: -d:  351

GRANITE   L: -d:  352                                                               14:39:19
```

SUMMARY OF CORRELATION RESULTS

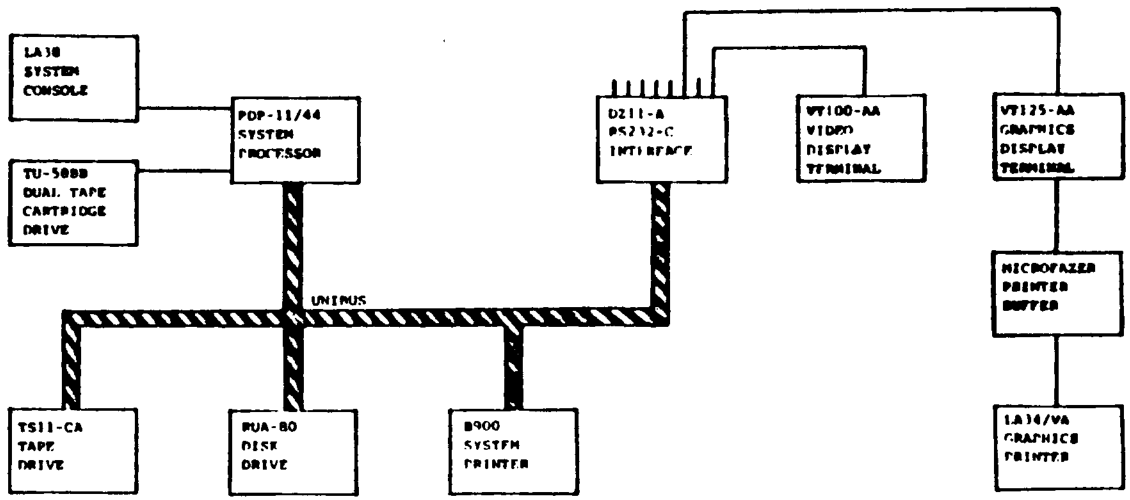
SYSTEM HARDWARE BLOCK DIAGRAM FOR RTMF CORE COMPUTER



SASMF HARDWARE

1	PDP-11/44 MINI COMPUTER WITH 1.0 MBYTE OF MEMORY
1	LA38 DECWRITER IV PRINTER TERMINAL CONSOLE
1	RUA-80 124 MBYTE DISK UNIT
1	TS11-CA 9-TRACK 1600 BPI TAPE UNIT (40 MBYTES PER REEL)
1	TU-58BB DUAL TAPE CARTRIDGE DRIVE (256 KBYTES PER CARTRIDGE
1	VT100-AA VIDEO DISPLAY TERMINAL
1	VT125-AA GRAPHIC VIDEO DISPLAY TERMINAL
1	LA34/VA DECWRITER IV GRAPHICS PRINTER
1	MICROFAZER 64K PRINTER BUFFER
1	B900 DATA PRODUCTS 900 LPM PRINTER

SASMF SYSTEM HARDWARE DIAGRAM



STAND-ALONE SPECTRUM MANAGEMENT FACILITY

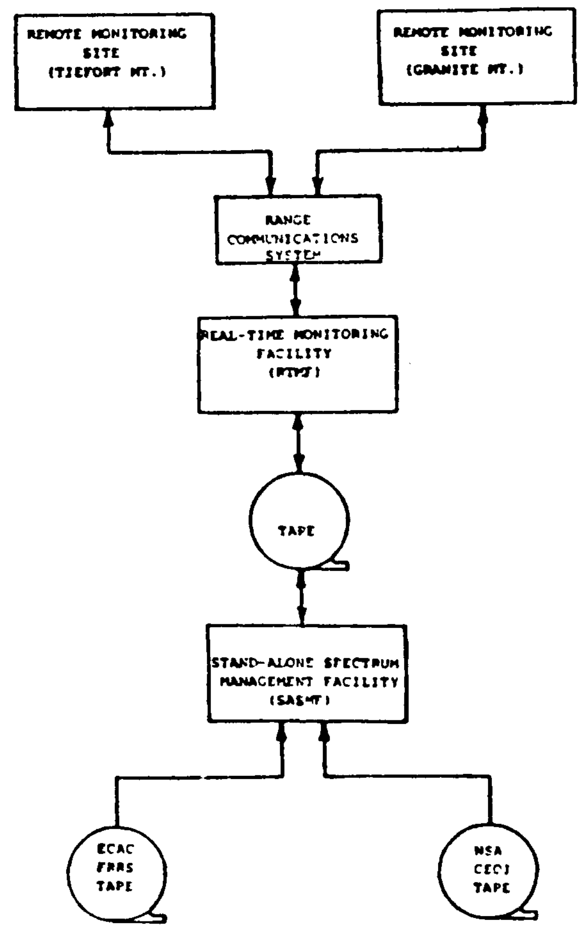
OFF THE SHELF HARDWARE TECHNOLOGY

- PDP-11/44 PROCESSOR AND PERIPHERALS

SOFTWARE TECHNOLOGY

- SPECTRUM MANAGEMENT DATA BASE
- REAL-TIME MONITORING FACILITY FILE GENERATION
- EMC ANALYSIS MODELS
- ARCHIVE REPLAY

SMECS SYSTEM DIAGRAM



SPECTRUM MANAGEMENT, ENGINEERING AND CONTROL SYSTEM (SMECS) (CONTINUED)

III. SUMMARY

- SMECS UTILIZATION TO IDENTIFY EMI SOURCES
- SMECS SYSTEM ENHANCEMENTS

SPECTRUM MANAGEMENT, ENGINEERING AND CONTROL SYSTEM (SMECS) (CONTINUED)

II. SMECS SYSTEM

- DEVELOPMENT GOALS
- STAND-ALONE SPECTRUM MANAGEMENT FACILITY (SASMF)
  - HARDWARE CONFIGURATION
  - FUNCTIONAL DESCRIPTION
  - CAPABILITIES
- REAL-TIME MONITORING FACILITY (RTMF)
  - HARDWARE CONFIGURATION
  - FUNCTIONAL DESCRIPTION
  - CAPABILITIES
- SYSTEM DISPLAYS

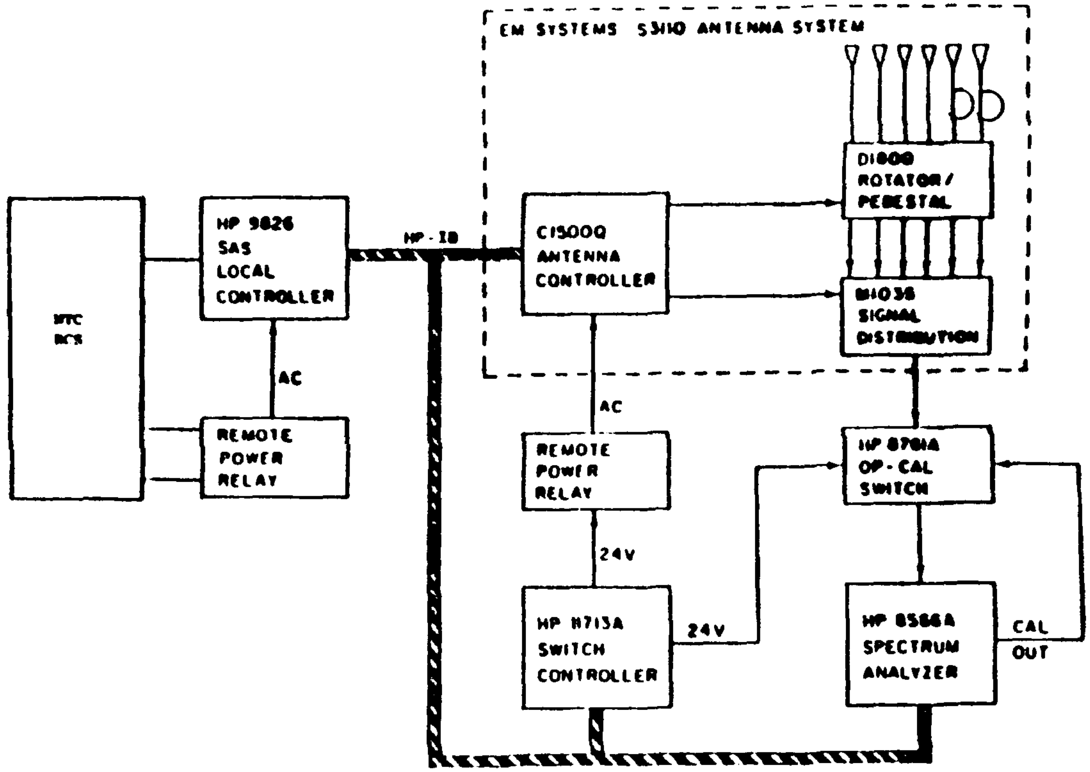
FUNDAMENTAL PROBLEMS

- LACK OF LOCAL COMMUNICATION/COORDINATION
- LACK OF EQUIPMENT DETAILS
- LACK OF MISSION UNDERSTANDING
- LACK OF IMPARTIAL TECHNICAL ADVICE

REAL-TIME MONITORING FACILITY FUNCTIONAL DESCRIPTION

- AUTOMATIC CONTROL AND DATA ACQUISITION FROM REMOTE SITES
- CORRELATION OF OBSERVED VERSUS EXPECTED SPECTRUM
- OPERATOR ALERTS ON PROTECTED AND PRIORITY FREQUENCIES
- PRIORITIZATION OF INTERFERENCE POTENTIAL
- ACHIVING OF SPECTRUM USAGE
- HARDCOPY OF SELECTED SPECTRUM SEGMENTS

SYSTEM HARDWARE BLOCK DIAGRAM FOR RTMF SAS



RTMF HARDWARE

	1	PDP-11/44 MINI COMPUTER WITH 1.0 MYBYTE OF MEMORY
	1	LA38 DECWRITER IV PRINTER TERMINAL CONSOLE
*	2	RL02 10 MBYTE DISK UNITS WITH REMOVABLE DISK PACKS
	1	TS11-CA 9-TRACK 1600 BPI TAPE UNIT (40 MBYTES PER REEL)
	1	TU-58BB DUAL TAPE CARTRIDGE DRIVE (256 KBYTES PER CARTRIDGE)
	1	VT100-AA VIDEO DISPLAY TERMINAL
	1	VT125-AA GRAPHIC VIDEO DISPLAY TERMINAL
	1	LA34/VA DECWRITER IV GRAPHICS PRINTER
	1	MICROFAZER 64K PRINTER BUFFER
*	1	LA120 DECWRITER III LINE PRINTER
*	1	HP59307A VHF SWITCH
*	1	IEC-11A IEEE-488 INTERFACE

UTILIZING SASMF TO IDENTIFY EMI

- FREQUENCY RESOURCE RECORD SYSTEM (FRRS)

  PROVIDES THE NTC SPECTRUM MANAGER WITH ALL REGIONAL FREQUENCY WITHIN A 175 MILE RADIUS OF FT. IRWIN

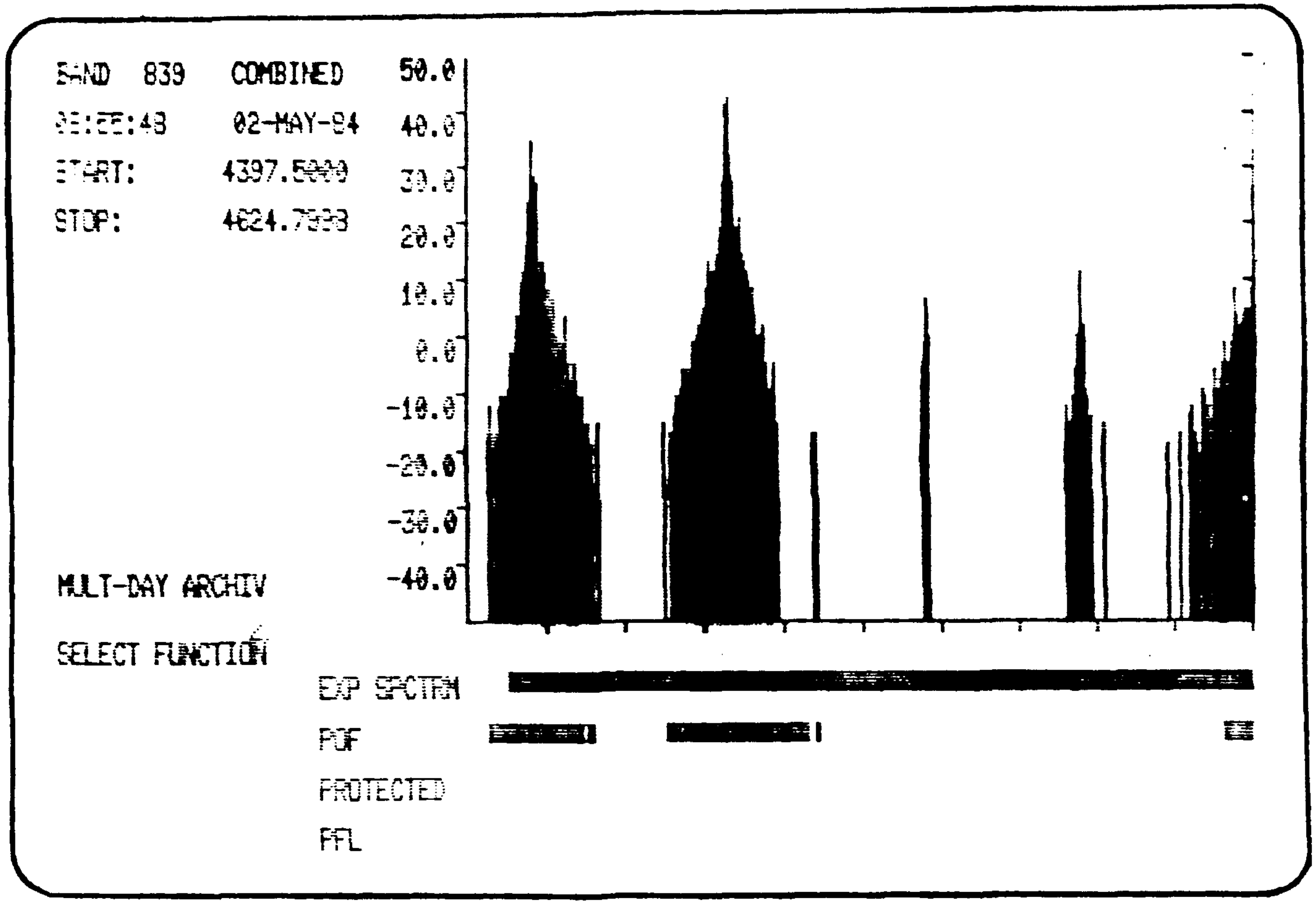
- FREQUENCY ASSIGNMENT FILE (FAF)

  PROVIDES THE NTC SPECTRUM MANAGER WITH ALL LOCAL FREQUENCY ASSIGNMENTS AT FT. IRWIN

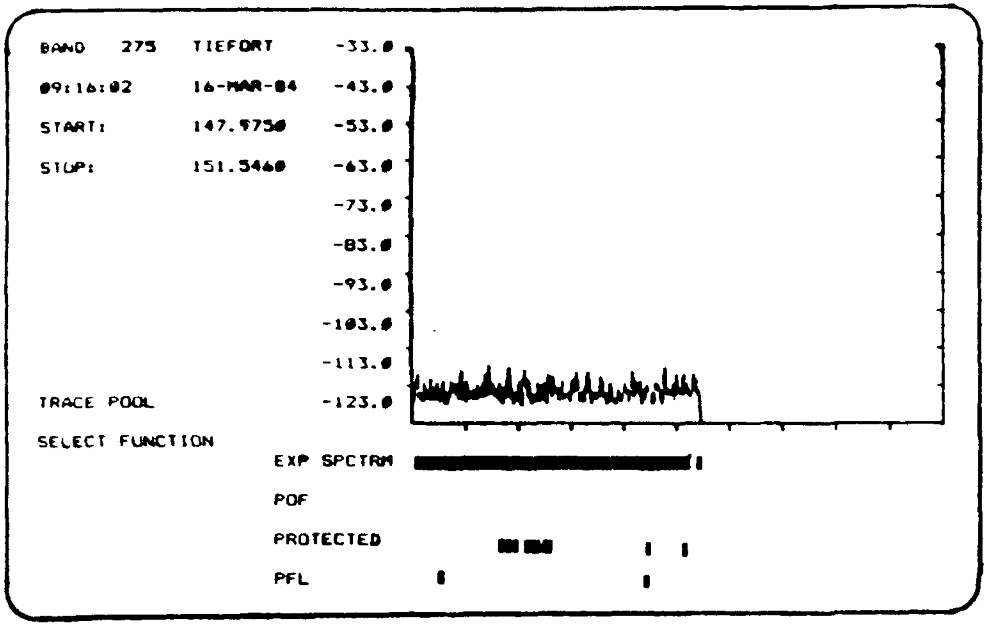
- ARCHIVE REPLAY

  PROVIDES THE NTC SPECTRUM MANAGER WITH OBSERVED SPECTRUM HISTORY AT FT. IRWIN

SASMF ARCHIVE REPLAY DISPLAY

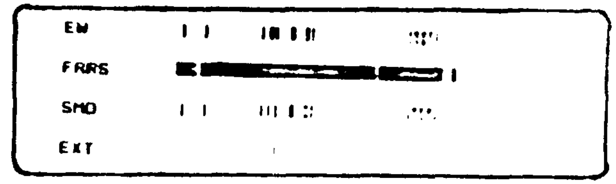


GRAPHIC DISPLAY OF SPECTRUM DATA

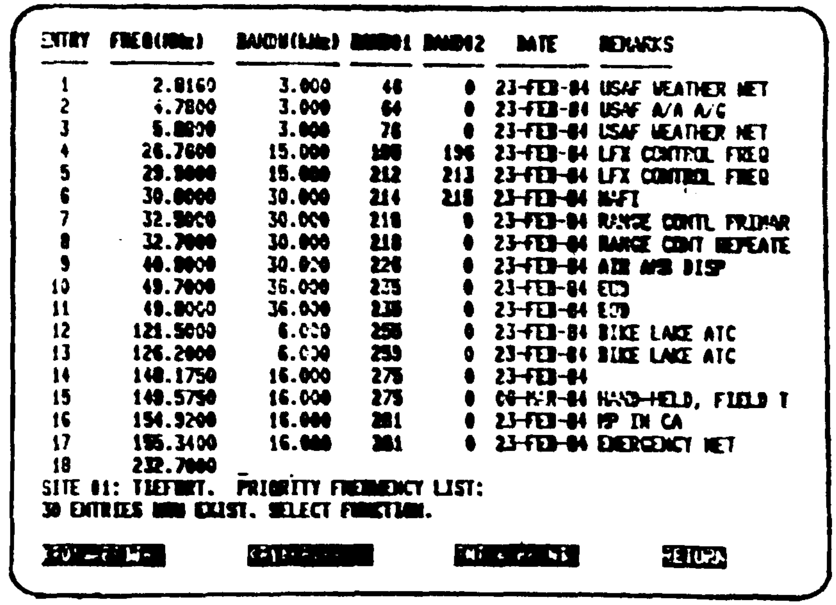


SPECTRUM OVERVIEW

ASSIGNMENT SOURCE



PROTECTED BAND DETAILS

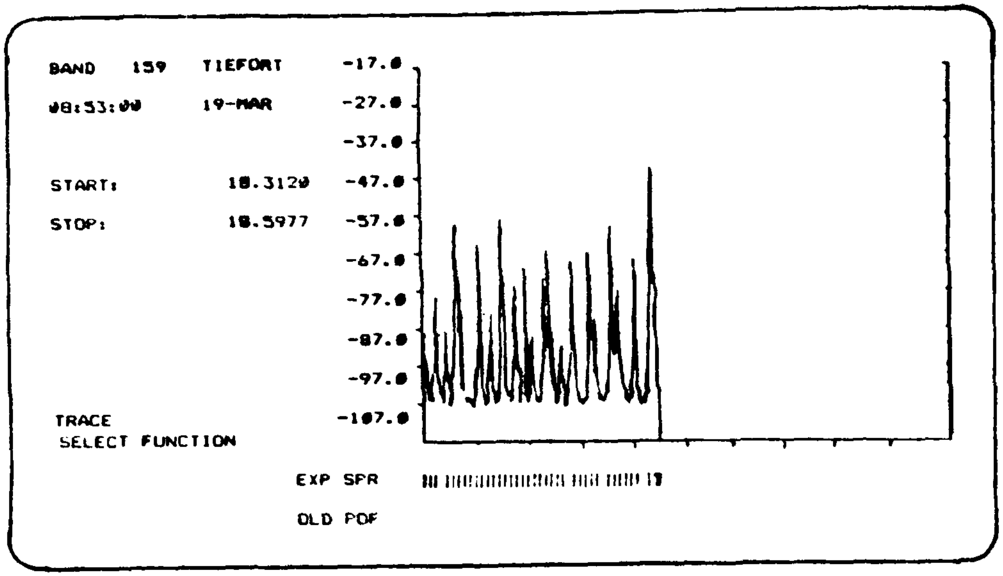


ENTRY	FREQ(MHz)	BANDW(kHz)	BAND#1	BAND#2	DATE	REMARKS
1	2.8160	3.000	48	0	23-FEB-84	USAF WEATHER NET
2	4.7800	3.000	64	0	23-FEB-84	USAF A/A A/G
3	5.8000	3.000	78	0	23-FEB-84	USAF WEATHER NET
4	26.7600	15.000	188	196	23-FEB-84	LFX CONTROL FREQ
5	29.8000	15.000	212	213	23-FEB-84	LFX CONTROL FREQ
6	30.0000	30.000	214	218	23-FEB-84	NAFI
7	32.3000	30.000	218	0	23-FEB-84	RANGE CONTL PRIMAR
8	32.7000	30.000	218	0	23-FEB-84	RANGE CONT REPEATE
9	40.8000	30.000	228	0	23-FEB-84	AIR ARB DISP
10	49.7000	36.000	235	0	23-FEB-84	ECD
11	49.8000	36.000	235	0	23-FEB-84	ECD
12	121.5000	6.000	258	0	23-FEB-84	BIKE LAKE ATC
13	126.2000	6.000	259	0	23-FEB-84	BIKE LAKE ATC
14	148.1750	16.000	275	0	23-FEB-84	
15	148.5750	16.000	275	0	08-MAR-84	HAND-HELD, FIELD T
16	154.9200	16.000	281	0	23-FEB-84	MP IN CA
17	155.3400	16.000	281	0	23-FEB-84	EMERGENCY NET
18	232.7000					

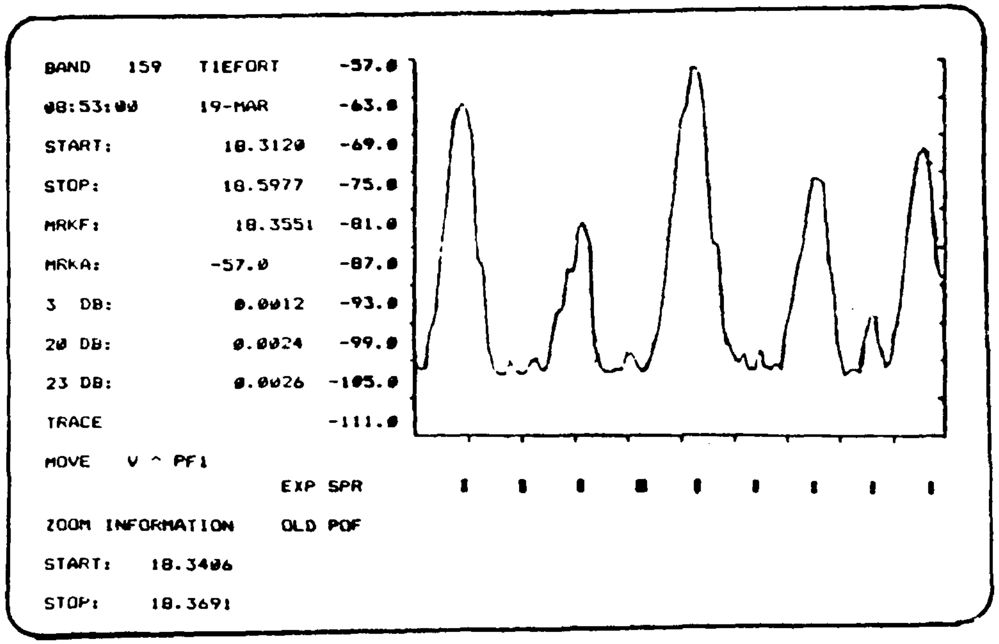
SITE 01: TIEFORT. PRIORITY FREQUENCY LIST:
30 ENTRIES NOW EXIST. SELECT FUNCTION.

RETURN

PRIORITY FREQUENCY EDIT DISPLAY



BANDWIDTH ANALYSIS: 3 DB
20 DB
(TRACE DATA) 23 DB



DISPLAY ZOOM: 2/1 TO 20/1
10/1 SHOWN

SPECTRUM MANAGEMENT, ENGINEERING AND CONTROL SYSTEM (SMECS)

I. INTRODUCTION

- BACKGROUND
- FUNDAMENTAL PROBLEMS
- SOLUTION
- ECAC INVOLVEMENT IN THE NTC

ECAC INVOLVEMENT IN THE NTC: BACKGROUND

- REQUESTED BY TRADOC TO APPRAISE RF COMPATIBILITY AND SUPPORTABILITY OF NTC SITE OPTIONS (FT. IRWIN, FT. HOOD, YUMA PROVING GROUNDS).
  - GOLDSTONE INTERFERENCE SUSCEPTIBILITY ANALYSIS
  - NTC INSTRUMENTATION SYSTEM DESIGN, SITING, AND OPERATIONAL ANALYSIS
  - DEVELOPMENT OF OPERATION DATA BASE FOR NTC

- REQUESTED BY TRADOC TO ASSIST IN THE NEGOTIATION OF A DoD/NASA MOU.

- REQUESTED BY TRADOC/FORSCOM TO IMPLEMENT NTC'S AGREED RESPONSIBILITIES OF MOU AT FT. IRWIN:
  - SPECTRUM MANAGEMENT ENGINEERING AND CONTROL SYSTEM (SMECS).
  - CONTINUED ANALYTICAL SUPPORT.
  - DIRECT SPECTRUM MANAGEMENT OF FT. IRWIN.

SOLUTION

- DoD/NASA MEMORANDUM OF UNDERSTANDING FOR COMPATIBLE OPERATIONS IN THE MOJAVE DESERT SIGNED JANUARY 1979

SMECS SYSTEM ENHANCEMENTS

APPROVED ENHANCEMENTS

- IMPROVEMENT OF POWER REGULATION AT THE REMOTE MONITORING SITES
- IMPROVEMENT OF THE COMMUNICATIONS LINK BETWEEN THE REAL-TIME MONITORING FACILITY CORE COMPUTER AND THE REMOTE MONITORING SITES

DESIRED ENHANCEMENTS

- PULSE CAPABILITY FOR PULSED EMISSION MEASUREMENTS

UTILIZING RTMF TO IDENTIFY EMI

- **PRIORITY FREQUENCY LIST**

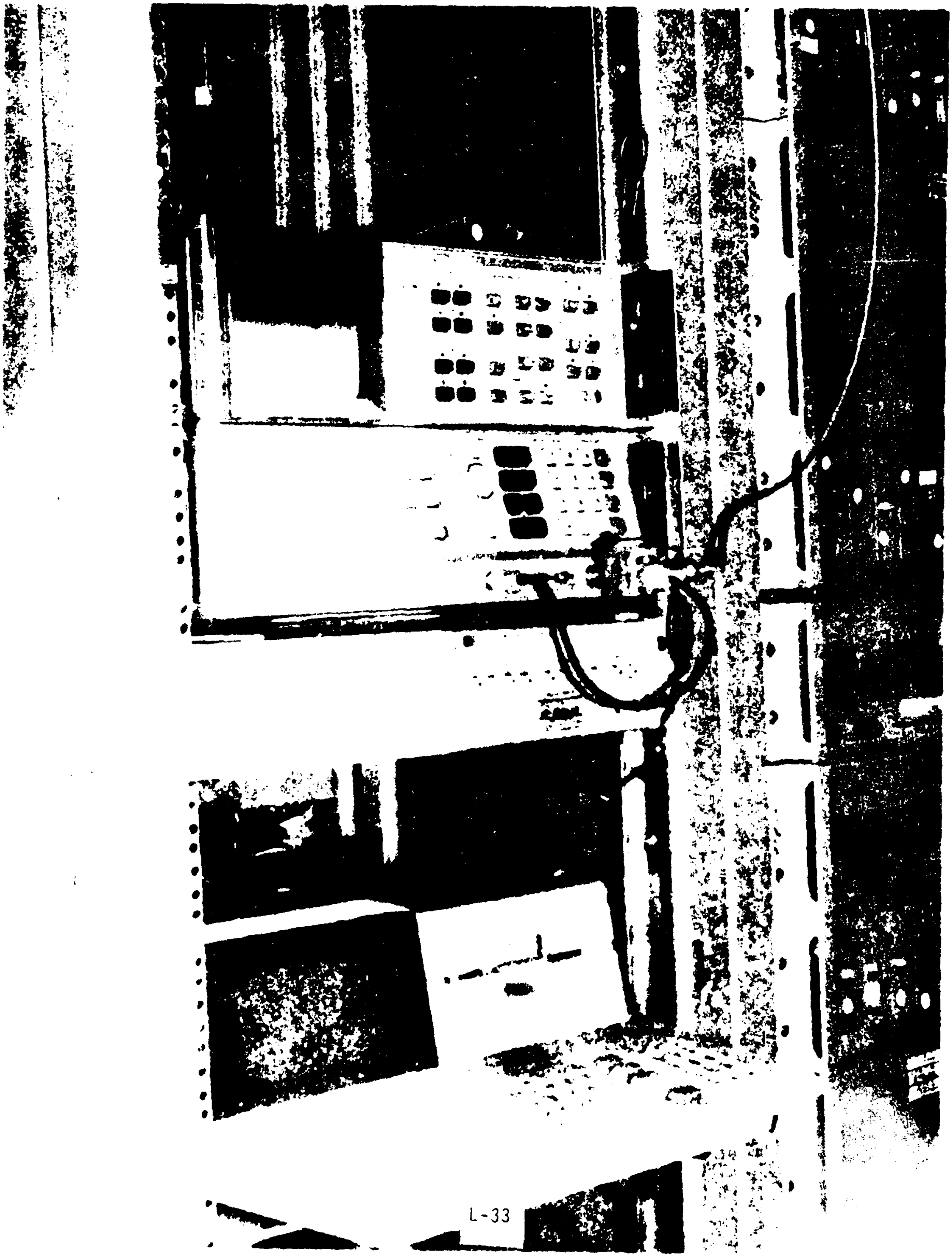
  PROVIDES THE NTC SPECTRUM MANAGER WITH A RECORD OF OBSERVANCES ON SELECTED FREQUENCIES

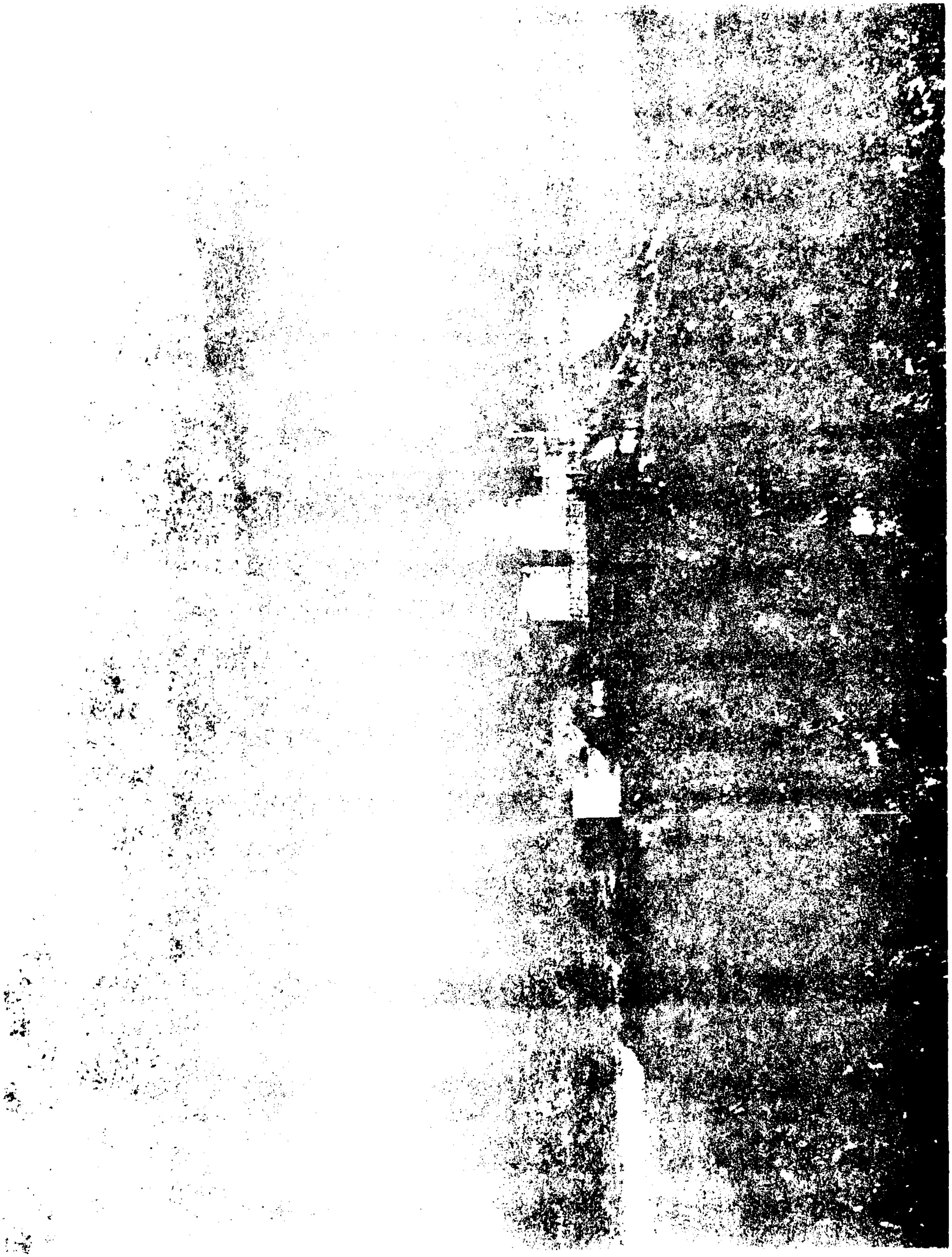
- **DIRECTION FINDING**

  PROVIDES THE NTC SPECTRUM MANAGER WITH THE CAPABILITY TO LOCATE THE ~~SOURCE~~ DIRECTION OF A SPECIFIC EMISSION

- **MANUAL CONTROL OF THE REMOTE SPECTRUM ANALYSIS SITE**

  PROVIDES THE NTC SPECTRUM MANAGER WITH THE CAPABILITY TO OBTAIN SPECTRUM ANALYZER TRACES ON SELECTED EMISSIONS





APPENDIX M

FORT HUNTER LIGGETT

JOLON, CALIFORNIA

ELECTROMAGNETIC INTERFERENCE (EMI) VAN SYSTEM

ENGINEERING SUPPORT EVALUATION REPORT

Scientific Support Laboratory
Fort Hunter Liggett (FHL)
Jolon, California

TABLE OF CONTENTS

LIST OF FIGURES

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF APPENDIX

ELECTROMAGNETIC INTERFERENCE (EMI) VAN SYSTEM

1. **INTRODUCTION.** The Electromagnetic Interference (EMI) Van System is support equipment for the Range Measuring System (RMS) which is part of the Radio Frequency Instrumentation Systems (RFIS) per Task Assignment #564.01, Systems Engineering for the RFIS.

2. **PURPOSE.** This report describes the EMI Van instrumentation system, subsystems and related accessories. The Systems Engineering support requirements to operate and maintain the EMI Van System are identified and delineated.

3. **SCOPE.**

a. This report is limited to the review and evaluation of the EMI Van System documentation for completeness and deficiencies. A technical survey of Scientific Support Laboratory (SSL) Engineering Division Branch and Group Leaders, Project Managers, and Systems Engineers was conducted to identify improvements and enhancements that will add to the overall capability and versatility of the system.

b. This limitation is due to the fact that the EMI Van System was designed, developed and assembled by a government agency under an interservice support agreement. The original system design requirements and specifications are not immediately available. Also, systems engineering has had limited access to the van and Combat Developments Experimentation Center (CDEC) is currently unable to deploy the van due to a shortage of personnel.

4. **BACKGROUND.** The EMI Van System is used to perform EMI frequencies surveillance and direction finding at Fort Hunter Liggett (FHL). It is also used to monitor authorized and assigned radio frequencies at FHL.

a. **Contracting Agency.** The Institute of Telecommunication Sciences (ITS), Department of Commerce, Boulder, Colorado facility was given an Interservice Support Agreement contract in late 1977 to develop an EMI Van for support of CDEC experiments. Acceptance tests were performed on the EMI Van System from 11 through 15 February 1980 at ITS, Boulder, Colorado. The van was delivered to CDEC, FHL on 29 February 1980.

b. **Operation and Maintenance.** The EMI Van System has been operated and maintained by Army personnel since its arrival at FHL. Scientific Support Laboratory (SSL) contractor has performed vehicle maintenance and provided engineering support upon request from the Frequency Management Branch (ATEC-E-EFM).

5. **DESCRIPTION.**

a. **Vehicle Configuration.** The EMI Van is a 1979 Ford, Econoline model, 1 1/2 ton cargo van, with four-wheel drive, 460 Cubic Inches Displacement (CID) engine and air-conditioning. Figures 1 and 2 are photographs of the van.

(1) Four-Wheel Drive. Vehicle Engineering and Manufacturing Company (VEMCO), Fort Wayne, Indiana, designed and installed the VX4 four-wheel drive. The front suspension system was reinforced by the SSL contractor because the front tires were continuously wearing out.

(2) Cargo Van Body. The steel cargo body is 12 feet long with 540 cubic feet of usable space. The entire cargo body was modified and instrumented by ITS.

(3) Van Mechanical Layout. Interior walls and ceiling were foam insulated and paneled. Indoor/outdoor carpet is installed over a plywood floor. Three table top work areas, two windows, and two storage cabinets are installed. There is no mechanical layout drawing of the cargo van.

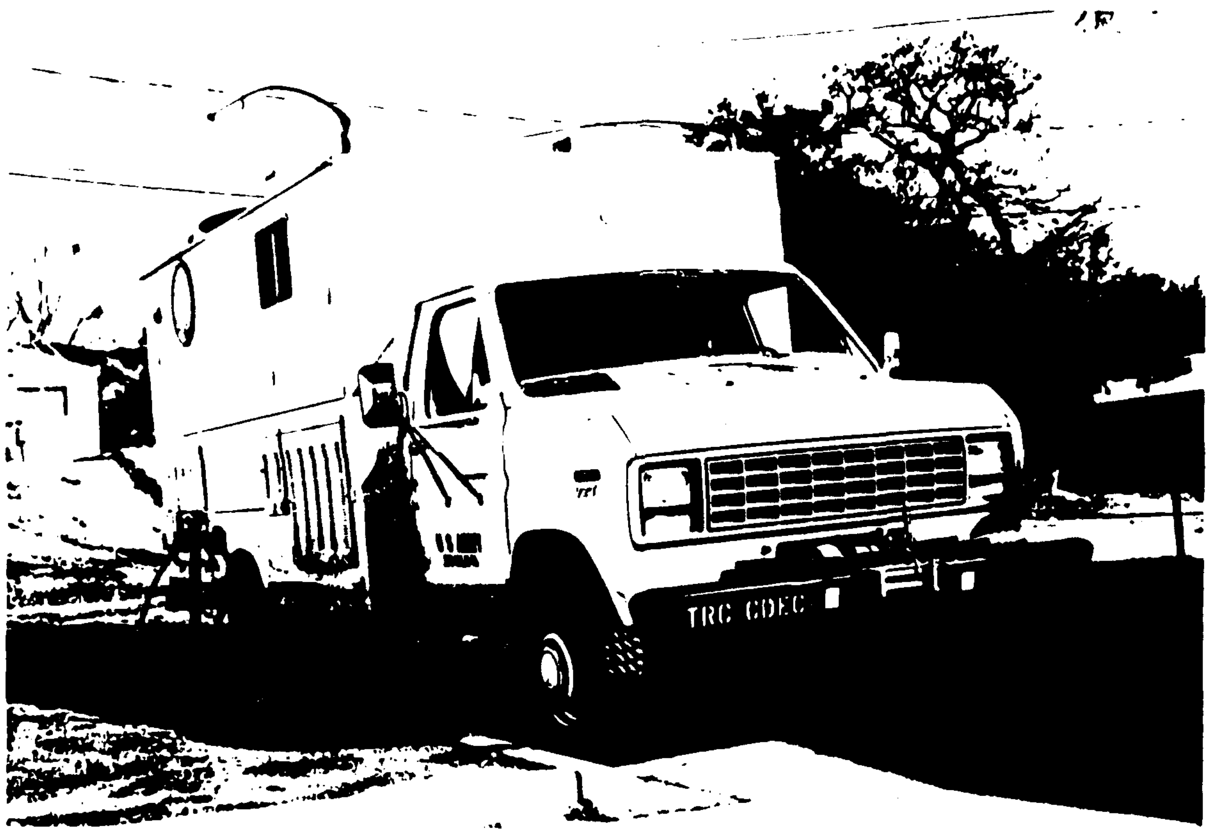


FIGURE 1. EMI VAN FRONT VIEW

FIGURE 2. EMI VAN REAR VIEW

(4) Subsystem Installations. An air-conditioner and heating unit, alternating current power distribution system and lighting were installed. EMI measurement equipment is rack-mounted in two 19" wide, ceiling-to-floor racks. Antennas for EMI frequencies measurement and communications are installed on the top, sides, and rear door of the van.

b. **EMI Systems**. The EMI systems are essentially two spectrum analyzers with preamplifiers, limiters, and switch selectable filters and antennas. The two manually-operated systems have a combined EMI surveillance frequency range of 100 hertz (Hz) to 18 gigahertz (GHz).

(1) EMI System I. The frequency range for EMI System I is 100 Hz to 1.5 GHz for EMI surveillance, and 30 megahertz (MHz) to 1.5 GHz for direction finding. Six switch selectable band-pass filters are used to cover the 30 MHz to 1.5 GHz frequency range for direction finding. Figure 3 (EMI System I Block Diagram) depicts the switching between antennas, noise diode, filters, preamplifiers and spectrum analyzer. In Figure 3, the appropriate antenna, or diode, is selected from the switching chassis at the operator's station. The output of the selected antenna or noise diode can be fed directly to the spectrum analyzer or via appropriate filter, limiter and preamplifier. The noise diode is used for system calibration. The System I Spectrum Analyzer is a Hewlett Packard (HP) 8568A, with an HP85680A Radio Frequency (RF) section, and an HP85662A display section. Figure 4 shows the HP8568A with the HP85662A display section. The HP85680A RF section is located behind the HP8568A analyzer shown in Figure 4.

(a) Antennas. EMI System I has a low and high frequency set of antennas, as shown in Figure 3. The low frequency antenna set consists of the omniranging, square loop and 918 MHz antennas. The two 918 MHz antennas are a single custom-designed microstrip direction finding antenna with a sum (Σ) and difference (Δ) output. Emphasis is placed on the 918 MHz frequency of the Range Measuring System (RMS) at FHL. The loop antenna is a custom-designed, 35-200 MHz square loop, directional finding

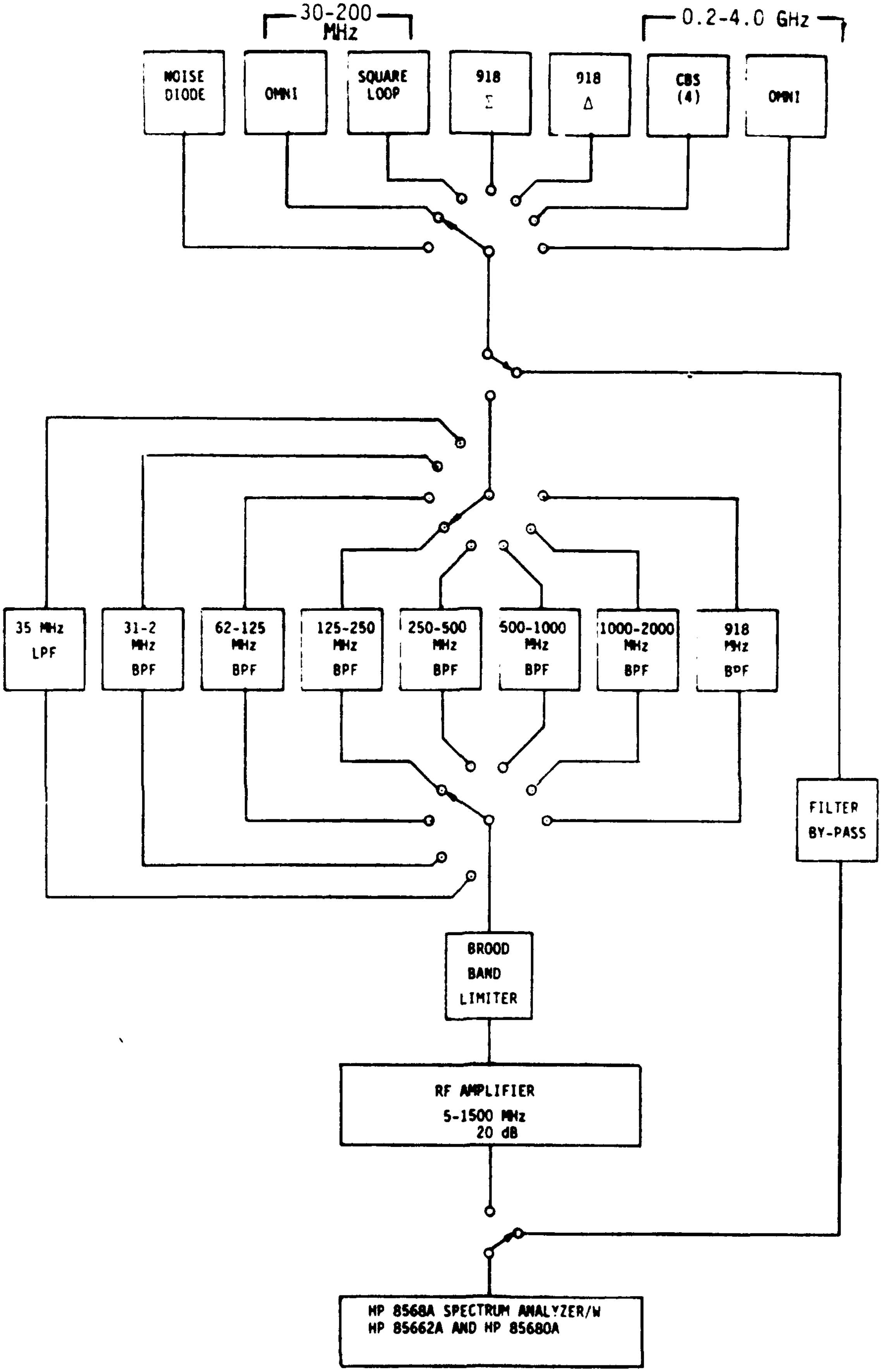


FIGURE 3. EMI SYSTEM I

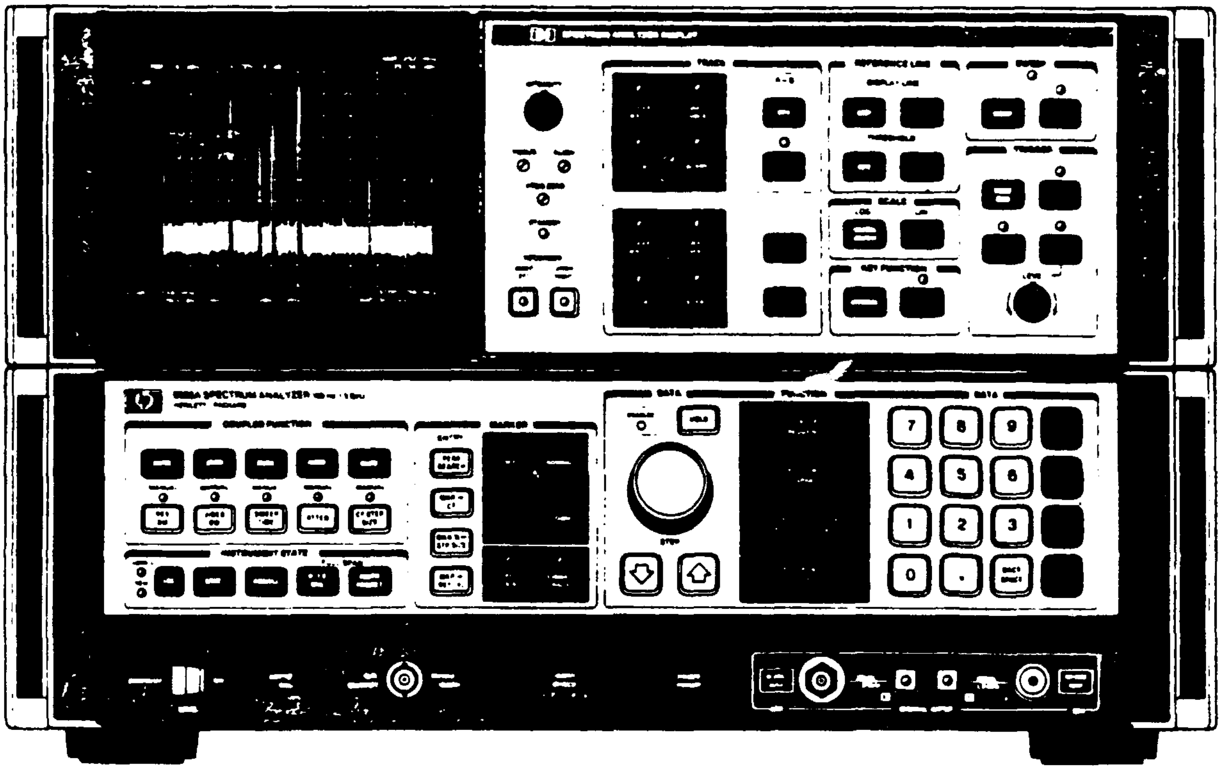


FIGURE 4. HP8568A SPECTRUM ANALYZER WITH HP85662A DISPLAY SECTION

antenna. The 30-200 MHz omniranging discone antenna was designed by ITS. The high frequency antenna set consists of four cavity back planar spiral antennas, with constant gain over the .2 - 4.0 GHz frequency band. Each cavity back spiral planar antenna covers the entire .2 - 4.0 GHz frequency band and is used for direction finding. The "omni" switch position may be used to connect another omniranging antenna or any type of antenna within the system frequency range. Note that only one antenna can be connected to the spectrum analyzer whether the low or high frequency antenna set is selected.

(b) Filters. The six switch selectable band-pass filters, with a frequency range of 31 MHz to 2.0 GHz (shown in Figure 3) are custom-designed, manually tuned filters. The six tunable band-pass filters are mounted on a separate 19" panel above the switching chassis at the operator's station. The 918 MHz band-pass filter has a 910 MHz to 926 MHz bandwidth. The 35 MHz and 918 MHz filters are mounted on the switching chassis.

(c) Limiter. The limiter (shown in Figure 3) is an HP11693A bidirectional, solid-state, passive device, with a frequency range of 0.1 GHz to 12.4 GHz. The limiting threshold is 5 milliwatts, with a maximum of one watt continuous average input power.

(d) Amplifier. The 5 MHz to 1,500 MHz amplifier (shown in Figure 3) is a custom-designed amplifier, with a minimum gain of 20 decibels (dB) and $\pm$ 0.5 dB gain flatness. The amplifier is mounted on the switching chassis.

(2) EMI System II. The frequency range for EMI System II is 1.5 GHz to 18 GHz for EMI surveillance and direction finding. Three switch selectable band-pass preamplifiers are used to cover the 1.5 GHz to 18 GHz frequency range for EMI surveillance and direction finding. Figure 5 (EMI System II Block Diagram) depicts the switching between antennas, noise diode, preselector, amplifiers and spectrum analyzer. In Figure 5, the appropriate

antenna or noise diode is selected from the switching chassis at the operator's station. The output of the selected antenna, or noise diode, is switched through the preselector to the spectrum analyzer via the appropriate band-pass preamplifier. The noise diode is used for system calibration. Figure 6 is a photograph of the System II HP8555A Spectrum Analyzer RF section, and HP8552B IF section, with the HP141T display section. The HP8555A Spectrum Analyzer frequency range is .01 GHz to 18 GHz.

(a) Antennas. In Figure 5, the "omni" antenna switch position may be used to connect an omniranging antenna or any type of antenna with a bandwidth within the system frequency range. The remaining four antennas are cavity back planar spiral antennas, with a frequency range from 2.0 to beyond 20 GHz.

(b) Preselector. The HP8445B preselector (shown in Figure 5) functions as a fixed-frequency, low-pass Yittrium-Iron-Garnet (YIG) filter for Direct Current (DC) to 1.8 GHz frequency range. The preselector functions as a voltage-tuned filter, from 1.8 GHz to 18 GHz. When the HP8555A Spectrum Analyzer is in the swept mode, the preselector functions as a swept selective tracking filter. The preselector may be electronically, or manually tuned.

(c) Preamplifiers. The three bandpass preamplifiers (shown in Figure 5) are high impedance, solid-state amplifiers, with constant gain over their frequency bandwidth. The 2.0 GHz - 4.0 GHz preamplifier has 20 dB minimum small signal gain. The 4.0 GHz to 8.0 GHz preamplifier small signal gain is 19 dB. Sixteen dB is the minimum small signal gain for the 8.0 GHz to 18.0 GHz preamplifier. The preamplifiers are mounted on the switching chassis.

(3) EMI Van Subsystems Description. See Appendix A for a complete inventory list of EMI Van equipment.

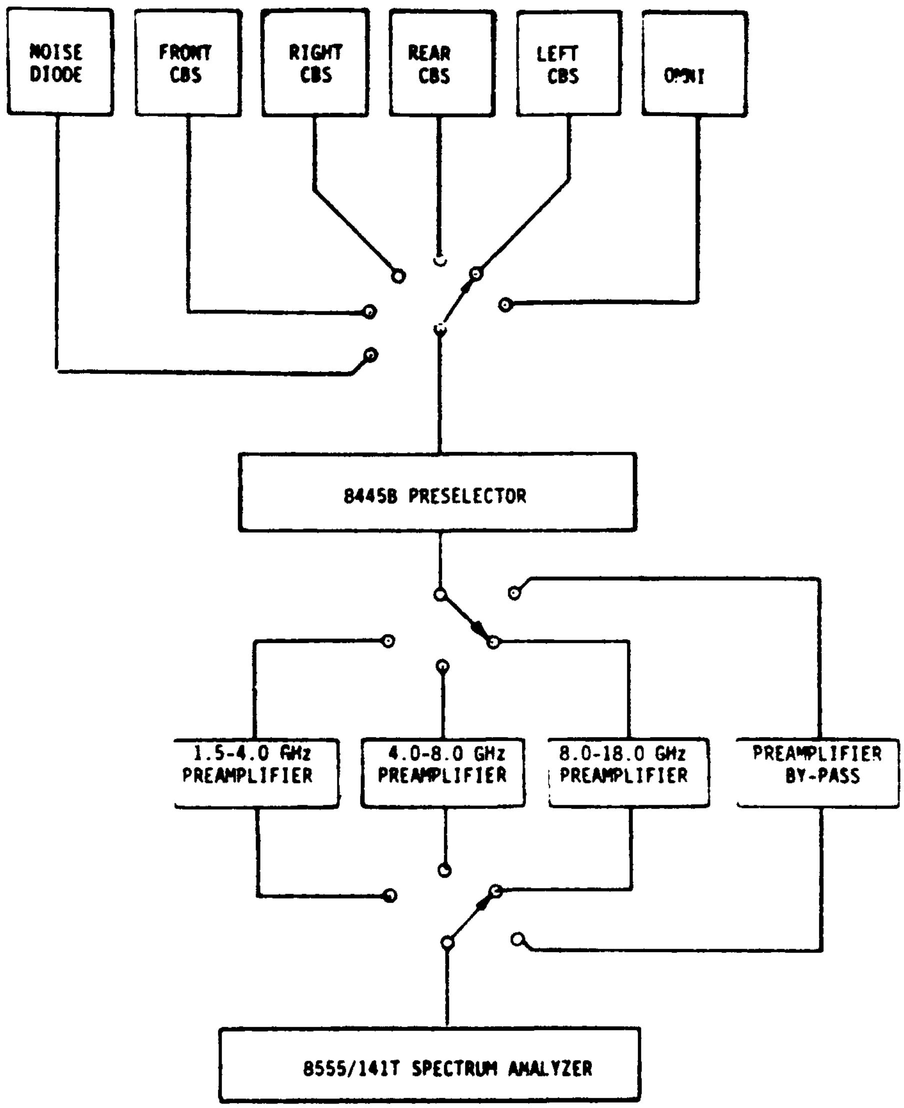


FIGURE 5. EMI SYSTEM II

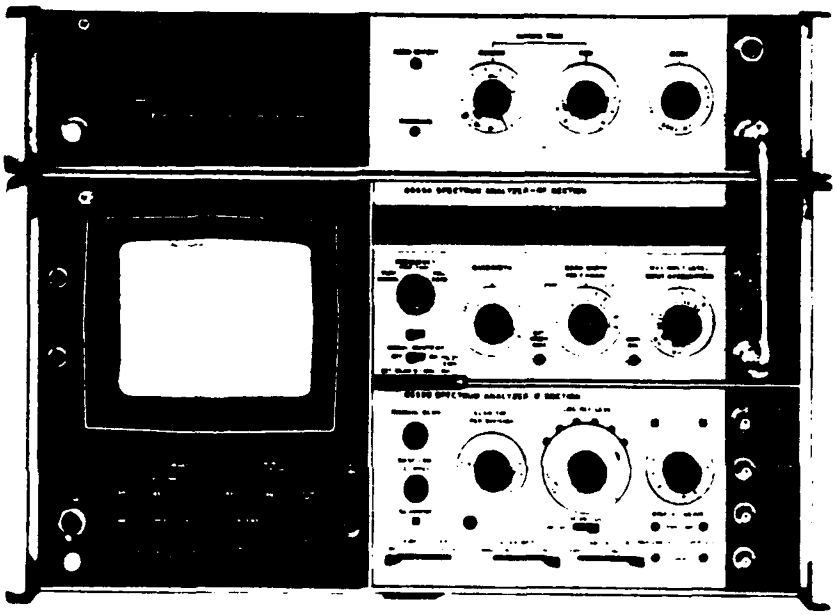


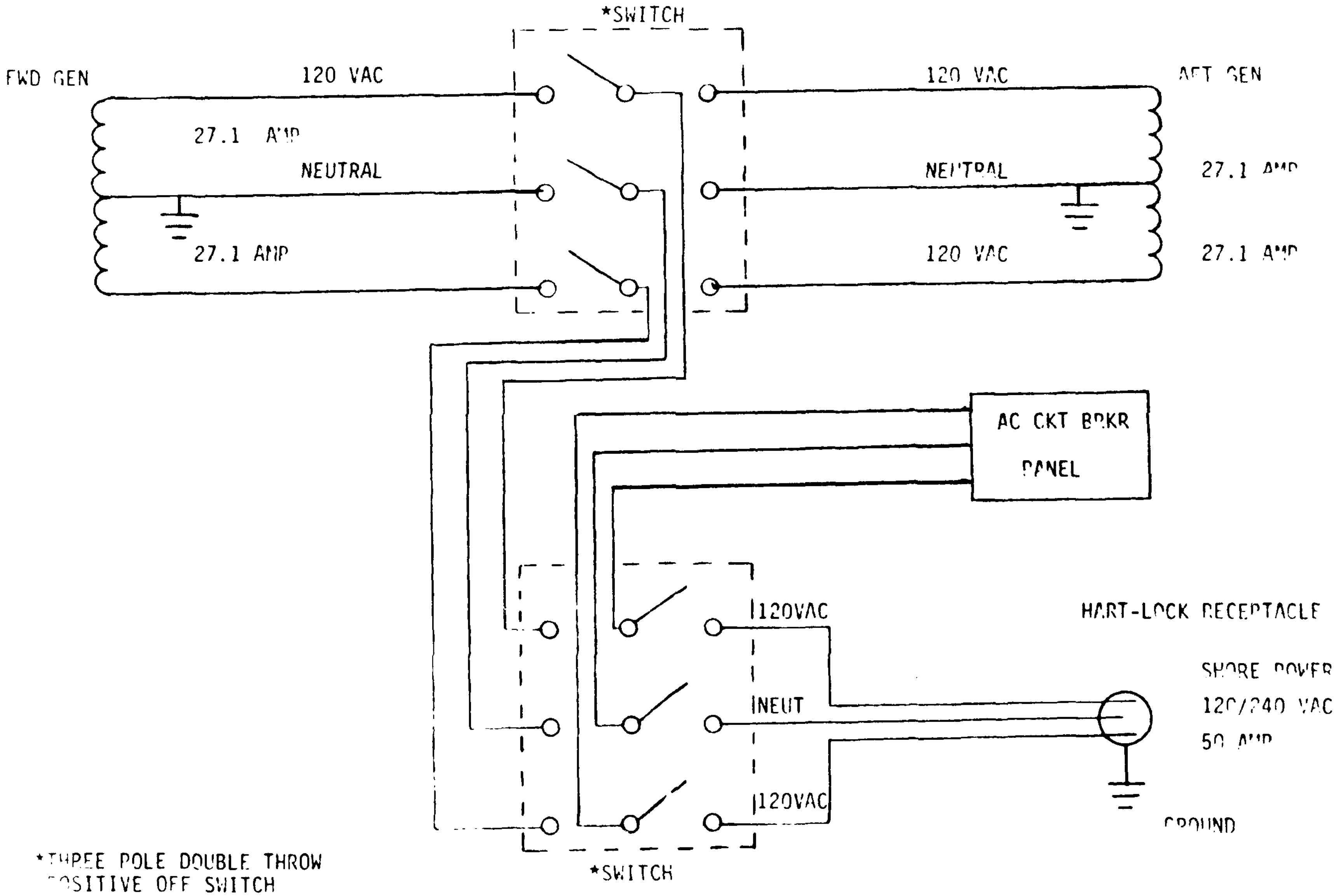
FIGURE 6. HP8555A SPECTRUM ANALYZER ASSEMBLY

(a) Alternating Current (AC) Power Distribution. AC power for the EMI measurement equipment and van lighting is supplied by two Onan Model 6.5 NH-3CR recreational vehicle electric generating sets. Each generator set consists of a two-cylinder, four-cycle, air-cooled, gasoline engine, with remote start and 12 volt motorized alternator cranking. The four-pole, revolving armature alternator produces 120 volts, 54.2 amperes, 60 hertz, single phase AC at 6,500 watts rated output. A schematic of the AC power distribution system is shown in Figure 7. The shore power receptacle shown in Figure 7 provides external AC power to the van when it is parked. The generator sets have separate fused battery charging circuits and start-stop controls. A block schematic and photograph of the circuit breaker panel load center for the generator sets are shown in Figure 8.

(b) Fuel System. The fuel system consists of two 18 gallon gas tanks for the generator sets and van engine. The fuel tanks are located on the left side of the van and the fuel indicators are switch selectable from the vehicle operator's console. Figure 9 is a block diagram of the fuel distribution system.

(c) Switching Chassis. The switching chassis front panel functions as the operator's control panel for configuring EMI Systems I and II. Figures 10 and 11 are switching block diagrams of EMI Systems I and II, respectively. Both systems are depicted on the front panel of the switching chassis. The pushbutton switch assemblies control radio frequency coax switches with indicator lamps which interconnect the system components. Figure 12 is a schematic of coax switches, numbers 1 and 2, which select the antennas for EMI System I. Figure 13 is a schematic of coax switch Number 7, which selects the antennas for EMI System II. Also shown in Figure 13 is coax switch Number 10 which selects system I or II.

(d) Direct Current Power Supply Chassis. Figure 14 is a wiring schematic of the Direct Current (DC) power supply chassis which is mounted in the rear of the second 19" equipment rack, just aft of the King

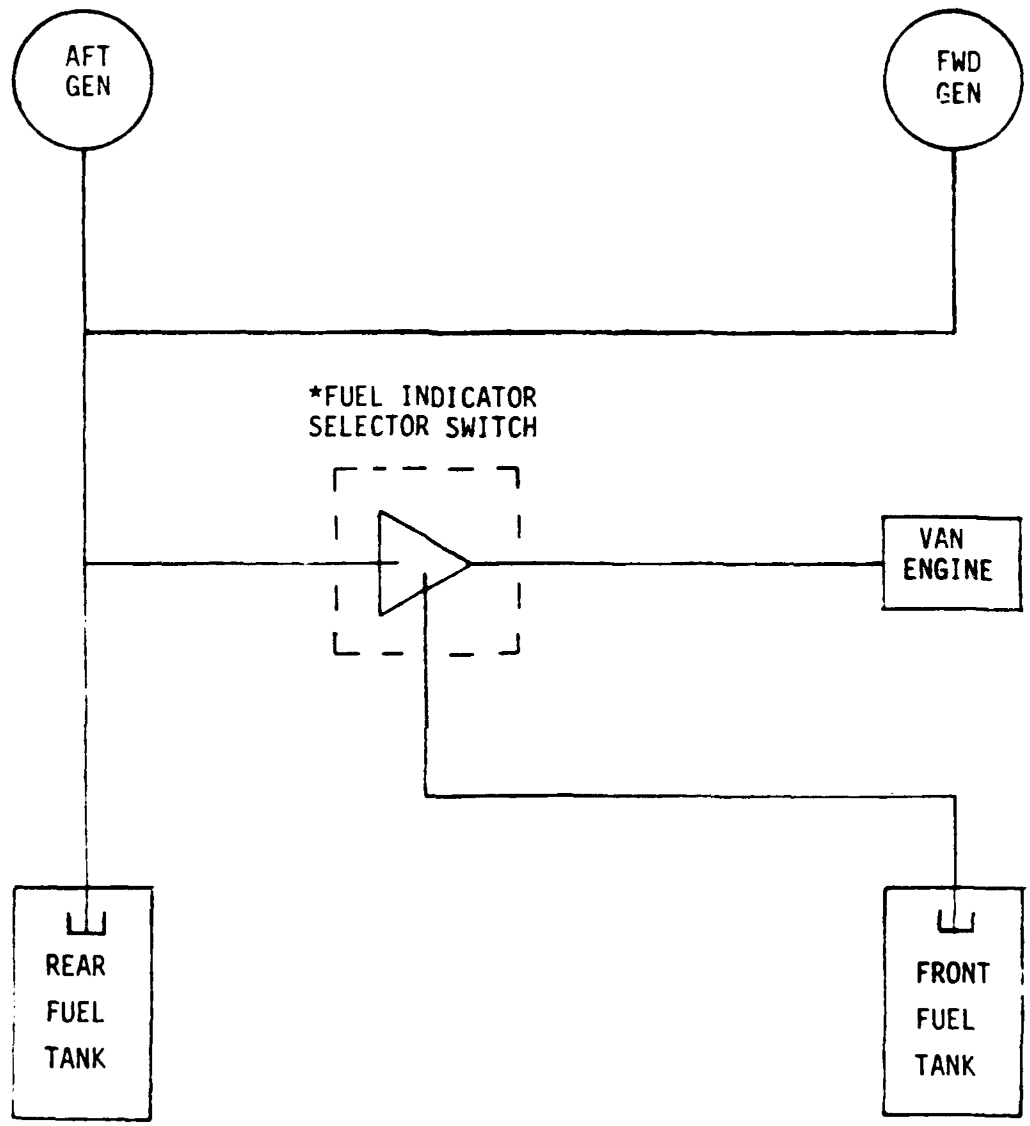


*THREE POLE DOUBLE THROW
POSITIVE OFF SWITCH

FIGURE 7. AC POWER DISTRIBUTION SYSTEM

LIGHTS	OUTLET ON ROOF	SHORT RACK	LONG RACK	AIR CON-DITIONER	WALL OUTLETS
15 AMP	15 AMP	20 AMP	20 AMP	20 AMP	15 AMP

FIGURE 8. AC CIRCUIT BREAKER PANEL LOAD CENTER



*NOTE: THIS SWITCH IS LOCATED ON THE LEFT BOTTOM SIDE OF THE VEHICLE OPERATOR'S DASHBOARD.

FIGURE 9. FUEL DISTRIBUTION SYSTEM

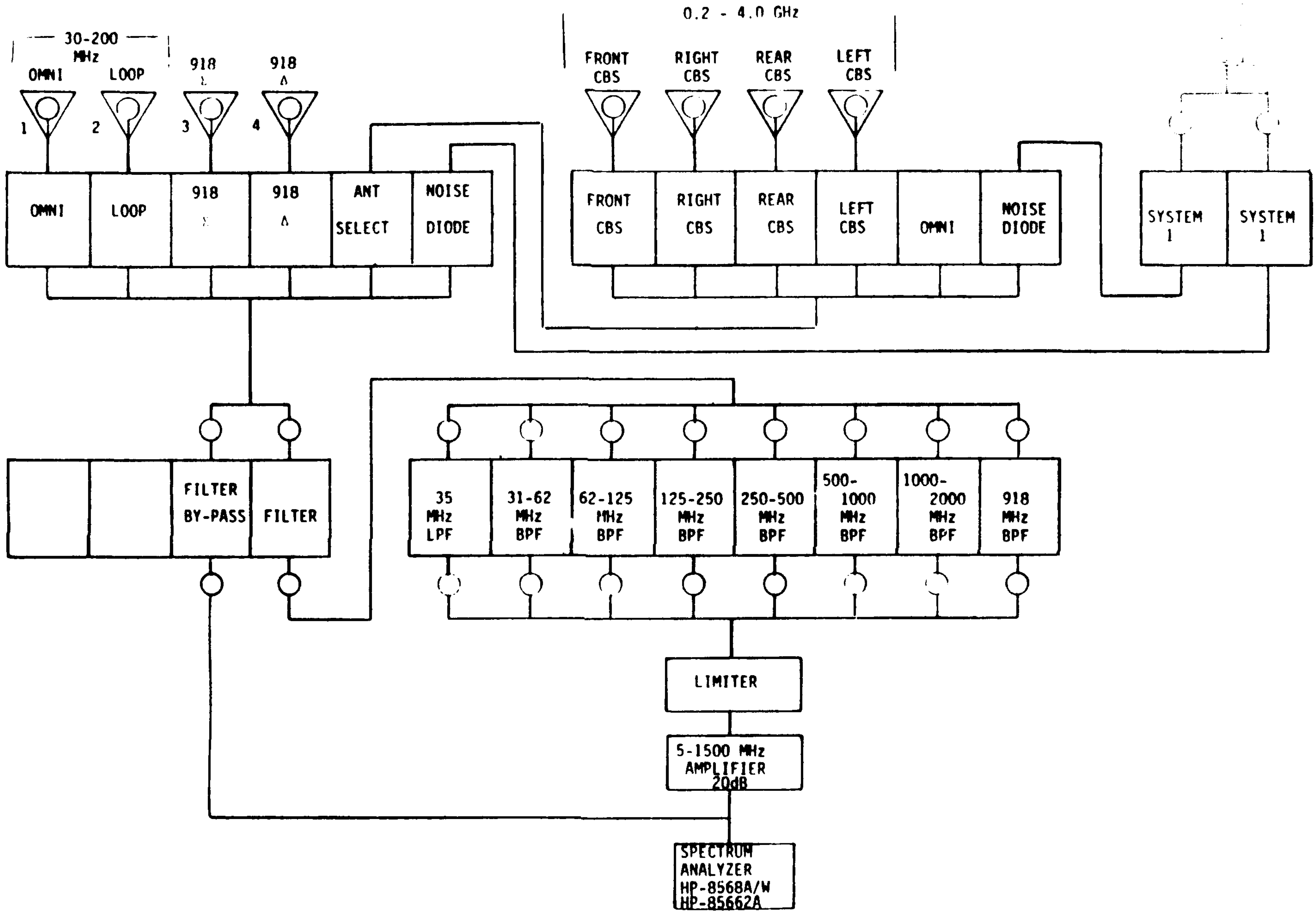


FIGURE 10. EMI SYSTEM I SWITCHING BLOCK DIAGRAM

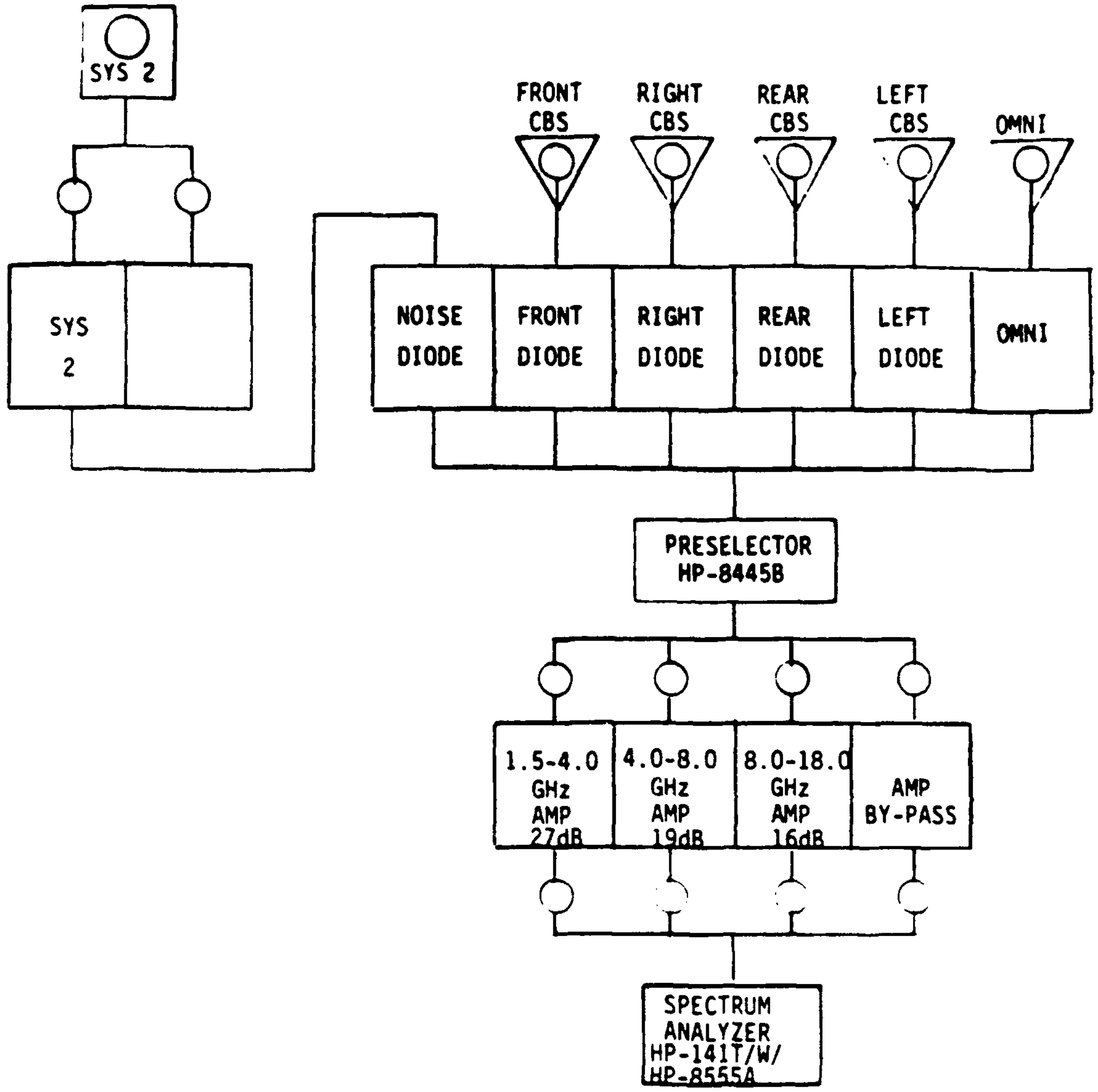


FIGURE 11. EMI SYSTEM II SWITCHING BLOCK DIAGRAM

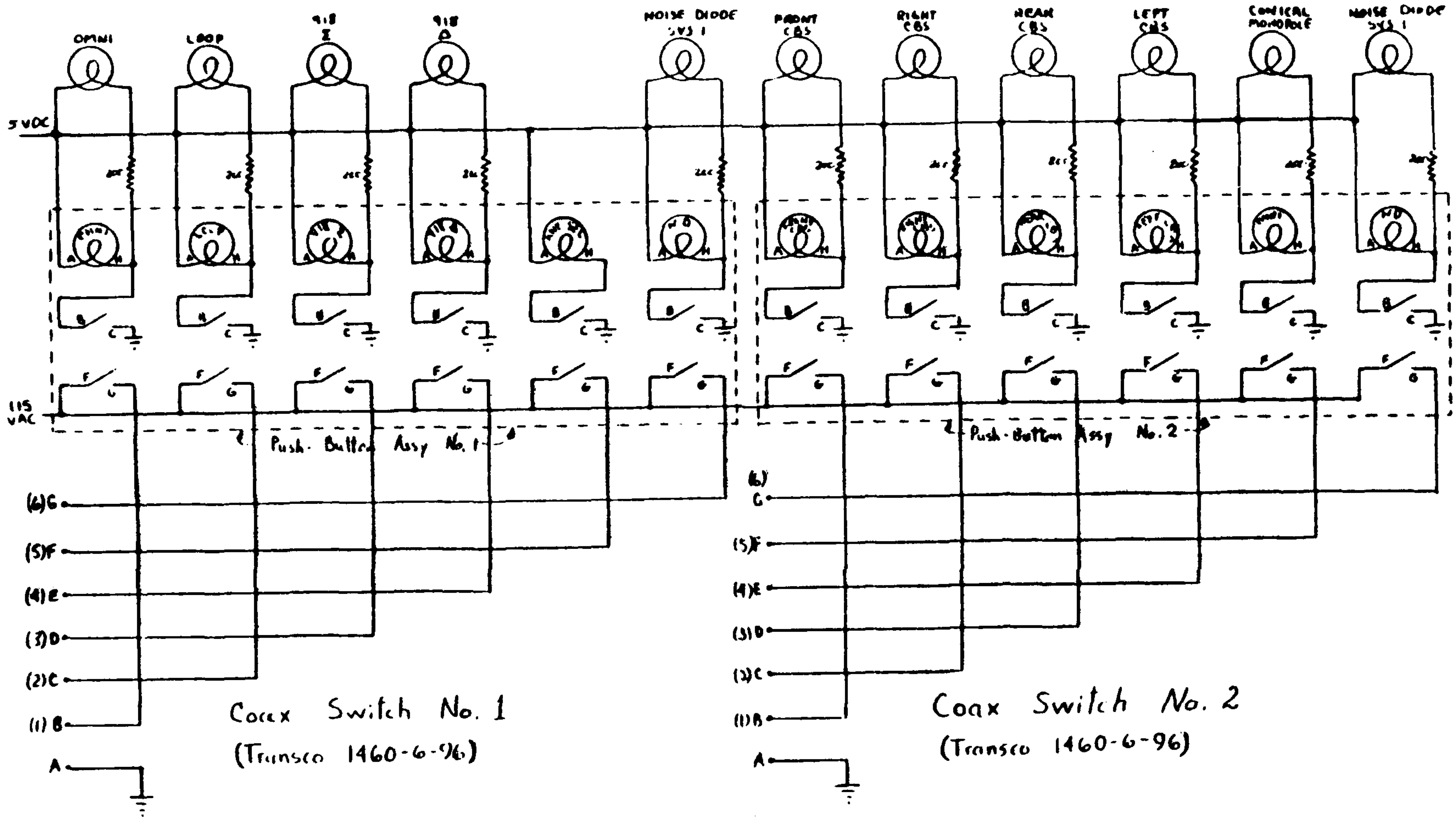


FIGURE 12. COAX SWITCHES, NUMBERS 1 AND 2 SCHEMATICS

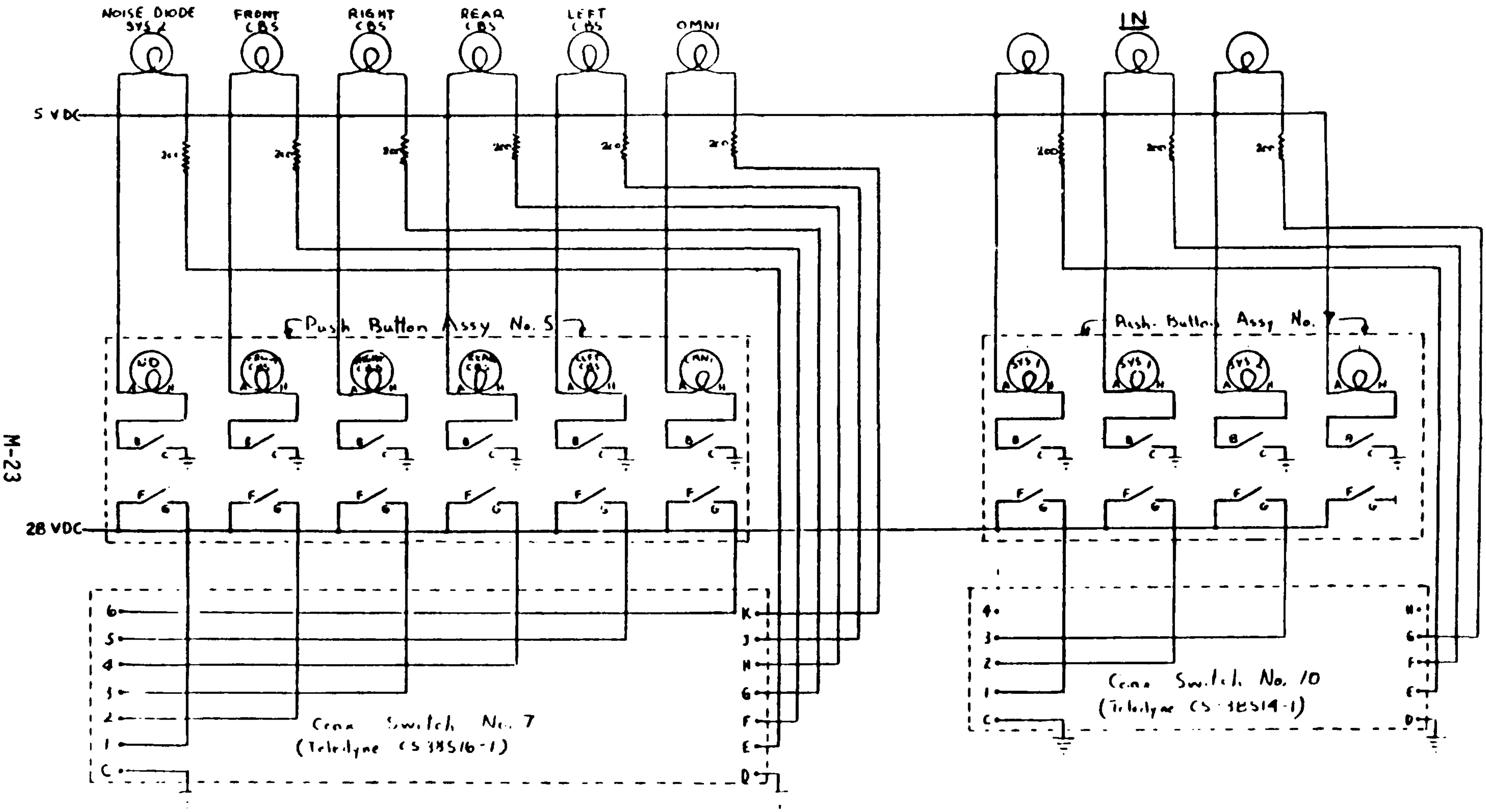
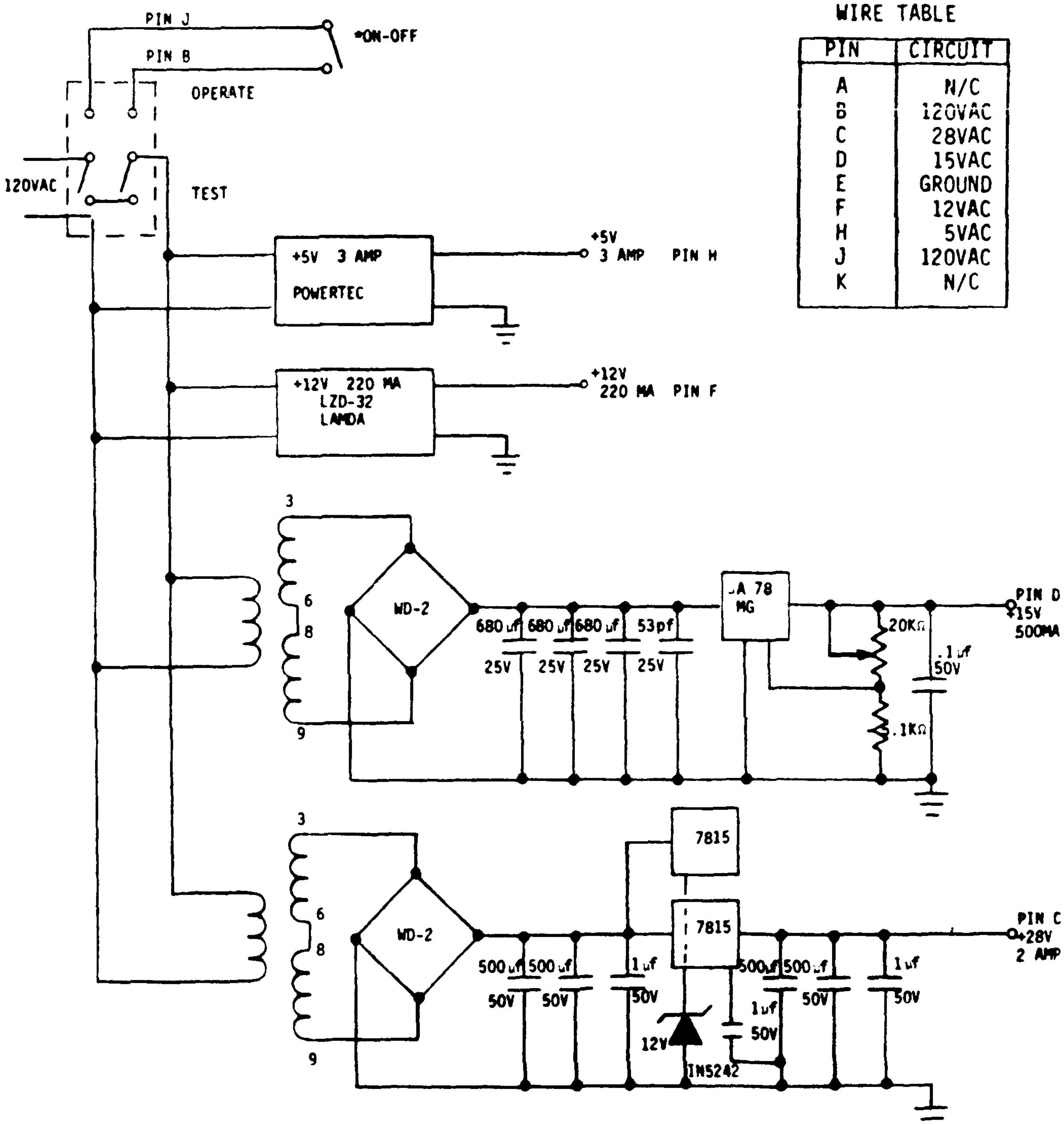


FIGURE 13. COAX SWITCHES NUMBERS 7 AND 10 SCHEMATICS

9 PIN CONNECTOR
WIRE TABLE

PIN	CIRCUIT
A	N/C
B	120VAC
C	28VAC
D	15VAC
E	GROUND
F	12VAC
H	5VAC
J	120VAC
K	N/C



*This is on the antenna switching panel.

Figure 14. DIRECT CURRENT POWER SUPPLY CHASSIS SCHEMATIC

KR87 Automatic Direction Finder. The DC power supply chassis supplies DC power to the switching chassis. The +5 volt power supply is used to power the indicator lamps. The +12 volt and +15 volt power supplies are used to power the solid state amplifiers and preamplifiers. The +28 volt power supply is used to energize the coax switches. The DC power supply chassis is controlled by the on-off switch on the switching chassis.

(e) Automatic Direction Finder. A King Radio, model KR87 Automatic Direction Finder (ADF), airborne type, with direction indicator is mounted in the 19" equipment rack, just below System II spectrum analyzer. It will provide automatic direction finding and audio reception for stations located in the 200 KHz to 1799 KHz frequency range. ADF indicator bearing accuracy is ± 3 degrees when the KR87 is tuned to an ADF station at a known magnetic heading.

(f) Communications Systems. Two tactical communication systems provide two-way radio telephone communication. An Associated Industries Model RT-5001, military-type RT-524/VRC receiver-transmitter provide communication in 30.00 MHz to 75.95 MHz range. RCA TAC100 communication receiver-transmitter provides communication over preassigned frequencies for FHL in the 138 MHz to 144 MHz government frequencies band.

(g) Scanning Receiver. Realistic Model PRO-2002 is a programmable, Very High Frequency (VHF) and Ultra High Frequency (UHF) scanning receiver. PRO-2002 can receive voice communications from Amplitude Modulated (AM) or Frequency Modulated (FM) stations. PRO-2002 receiver can be programmed to monitor or scan up to 50 frequency channels continuously. Also the PRO-2002 can be programmed to search a given frequency band for new stations.

(h) Air Conditioning System. Instamatic Model IM24 air-conditioner provides 9,400 BTU of cooling and heating for the van. It is installed on the van roof with flush-mounted ceiling controls. The conditioner unit is powered from the AC power distribution circuit breaker panel load center as shown in Figure 8.

(i) Video Monitor. A Videotek Model RM-12 color monitor is mounted in the 19" equipment rack above the system II spectrum analyzer. The 12" color monitor is used to monitor local and special video channels. Also, the monitor can be used to support photo-optics field experiments. The monitor is powered from the AC power distribution system.

6. DOCUMENTATION.

a. The documentation is insufficient to thoroughly know and maintain the EMI van systems. Table 1 is a list of EMI van drawings which are mostly engineering sketches. A typical example is Figure 12, "Coax Switches Numbers 1 and 2 Schematics". The drawings without an asterisk in Table 1 were developed for the report description section. The drawings with an "*" were delivered with the EMI van.

b. Table 2 is a list of EMI van manuals and procedures. It is a complete listing of Original Equipment Manufacturers (OEM) manuals for the equipment installed in the van. Notice there is only one operating procedure for the van which is the Army's "Vehicle Maintenance Standard Operating Procedure". The general condition of existing documentation is good.

7. DEFICIENCIES.

The EMI Van operation and mission capabilities are seriously restricted because of the following:

a. Inoperative Equipment.

(1) The HP8445B Preselector and HP8555A Spectrum Analyzer are inoperative which precludes the EMI System II from being used.

TABLE 1. LIST OF EMI VAN DRAWINGS

EMI System I Block Diagram.

EMI System II Block Diagram.

AC Power Distribution System Schematic.

AC Circuit Breaker Panel Load Center Drawing.

Fuel Distribution System Drawings.

EMI System I Switching Block Diagram.

*Coax Switches Numbers 1 and 2 Schematic.

*Coax Switches Numbers 3 and 4 Schematic.

*Coax Switches Numbers 5 and 6 Schematic.

*Coax Switches Numbers 8 and 9 Schematic.

*Coax Switches Numbers 7 and 10 Schematic.

Direct Current Power Supply Chassis Schematic.

*Lark Engineering Filters Design Data Sheets and Sketches.

*Preamplifiers and Amplifiers Design Data Sheets and Sketches.

*Miscellaneous Antenna Beamwidth and Gain Patterns.

*Miscellaneous Historical Notes and Documents.

EMI System II Switching Block Diagram.

NOTE: The drawings preceded with an asterisk were delivered with the EMI van.

TABLE 2. LIST OF EMI VAN MANUALS AND PROCEDURES

KING KR87 Automatic Direction Finder Manual.

Vehicle Maintenance Standard Operating Procedure.

Hewlett-Packard Model 1332A X-Y Display Operation and Service Manual.

REALISTIC Model PRO-2002 Scanner Owners Manual.

Manual of Regulations and Procedures for Radio Frequency Management.

Tables of Frequency Allocations.

AN/VRC-12 Series of Radio Sets Handbook.

Hewlett-Packard Model 8445B Automatic Preselector Operating and Service Manual.

Hewlett-Packard Model 141T Display Section Operating and Service Manual.

Hewlett-Packard Model 8555A Spectrum Analyzer, Radio Frequency Section Operating Manual.

Hewlett-Packard Model 8552B Spectrum Analyzer, Intermediate Frequency Section Operating and Service Manual.

Hewlett-Packard Model 8568A Spectrum Analyzer Operation and Service Manual.

Videotek Model RM-12 Color Monitor Service Manual, two each.

Vehicle Operator Preventive Maintenance Checksheet.

Onan Operators Manual for R.V. Electric Generating Sets.

Onan Installation Guide for R.V. Electric Generating Sets.

Onan Instruction Sheet E218a.

VEMCO VX4 Four-Wheel Drive.

(2) The Instamatic IM 24 air-conditioner cooling compressor is defective. The cooling compressor has been ordered, but the delivery date is not known. Lack of van air-conditioning could impact the EMI system operator proficiency and induce operator fatigue. Has been repaired

(3) The forward 6.5 kilowatt generator frequency meter needs to be wired electrically. The frequency meter was not wired when the van was delivered to FHL. Has been repaired

(4) The Scientific-Atlanta Microwave Measurement Receiver is inoperative (test equipment).

b. **Operations.**

(1) The EMI Van systems operators need to be trained in EMC practices, measurement, test, and analysis techniques.

(2) There are no system descriptions of the existing EMI van systems.

(3) There are no EMI systems comprehensive technical operating procedures, except those presented in Original Equipment Manufacturer's (OEM) manuals.

(4) On-the-job-training (OJT) is the only training available for the EMI van systems operators.

(5) The EMI Van operator's station has no work chair or stool.

(6) There are no EMI Van systems comprehensive managerial operating policies or procedures.

c. **Maintainability.** There are no specified spares requirements for the EMI van. The critical maintenance items for the EMI van are:

(1) VEMCO Four-Wheel Drive: There is no scheduled periodic maintenance procedure and VEMCO is no longer in business.

(2) The 30-200 MHz LA-20 Square Loop Direction Finding Antenna: Dunn Technical Associates are no longer in business. Proprietary rights to the antenna design were acquired by TECOM, Inc., Canoga Park, California.

(3) The 30-200 MHz Omniranging Discone Antenna (designed by ITS): The antenna design specifications could be lost due to personnel attrition.

(4) Spectrum Analyzers: There are no scheduled periodic calibration or maintenance procedures.

d. **Missing Documentation.** The list of missing documents shown in Table 3 is a compilation of documentation that will be beneficial for future van improvements, upgrades, maintenance and operations.

8. **GROWTH RECOMMENDATIONS.** The growth recommendations and improvements listed in Table 4 were obtained from a memorandum questionnaire survey of of Engineering Division Branch and Group Leaders, Project Managers, and Systems Engineers. The survey question regarding growth recommendations is given below:

- Functional additions that will add to overall capability and versatility of the system.
- Improvements needed in existing functions.

9. **CONCLUSIONS AND RECOMMENDATIONS.**

a. **Conclusions.** The EMI Van can currently be used only to perform EMI frequencies surveillance and direction finding in the 100 Hz to 1.5 GHz frequency range. This limitation is due to EMI System II being inoperative.

TABLE 3. LIST OF MISSING EMI VAN SYSTEM DOCUMENTS

EMI measurement equipment, ceiling to floor, 19" rack, electrical and mechanical drawings.

Alternating current power distribution system drawings.

Direct current power distribution system drawings.

EMI van mechanical layout drawings.

Switching chassis electrical and mechanical drawings.

EMI Van Systems operational procedures.

Spare parts list.

Vehicle periodic maintenance schedule.

EMI measurement equipment periodic calibration and maintenance schedule.

EMI Van Systems interface drawings.

TABLE 4. SUMMARY OF EMI VAN GROWTH RECOMMENDATIONS
SURVEY RESULTS WITH COMMENTS

TYPE OF RESPONSE
U = UPGRADE
I = IMPROVEMENT
G = GROWTH

	RESPONSES	COMMENTS
G	EMI Van be instrumented as a test set for ELOSS.	Conduct an engineering feasibility study to determine project cost and viability.
G	EMI Van be instrumented with night vision equipment.	Conduct an engineering feasibility study to determine project cost and what type of night vision equipment.
G	EMI van be instrumented to sense, alarm, and record illuminations in the ranges of the commonly used lasers and laser designators at FHL for the safety of unprotected personnel.	Conduct an engineering feasibility study to determine project cost, viability and what type of instrumentation equipment.
U	Motorola Data Encryption Standard (DES) radios be installed in EMI van.	Conduct an engineering feasibility study to determine project cost. Mandatory requirement if FHL range communications implement DES radios.
G	Pan and tilt mechanism be installed on the EMI van for video usage.	Conduct an engineering feasibility study to determine project cost and viability.
I	Someone should be assigned to learn the total operation (electronically) of the van.	More than one person should learn to operate and maintain the EMI van systems and subsystems in order to support 24 hour experiments.
I	Antennas should be checked for VSWR, antenna pattern characteristics, and gain vs. frequency.	Cavity backed planar spiral antennas have to be checked on an antenna range.
I	Field survey trips be made to Stanford Research Institute (SRI) and Vandenberg AFB to obtain ideas for improvement of the existing EMI van capabilities.	White Sands, N.M. and Point Mugu testing range also have EMI vehicles and test facilities.

b. Recommendations.

(1) The electrical and EMI van systems interface drawings listed in Table 3 be developed first and the remaining documents at a later date.

(2) Inoperative equipment deficiencies be corrected expeditiously.

(3) An EMI Van scheduled periodic maintenance procedure should be developed and implemented.

(4) Scheduled periodic calibration and maintenance procedures should be developed and implemented for the EMI van spectrum analyzer and other identified equipment.

(5) A ruggedized navigation magnetic compass should be procured and installed in the EMI van.

(6) An engineering study should be made to determine what type of EMI noise suppression networks should be procured and installed on the van engine ignition system and 6.5 Kw generator sets.

(7) Field survey trips should be made to other testing ranges or facilities to observe and study their Electromagnetic Compatibility (EMC) programs.